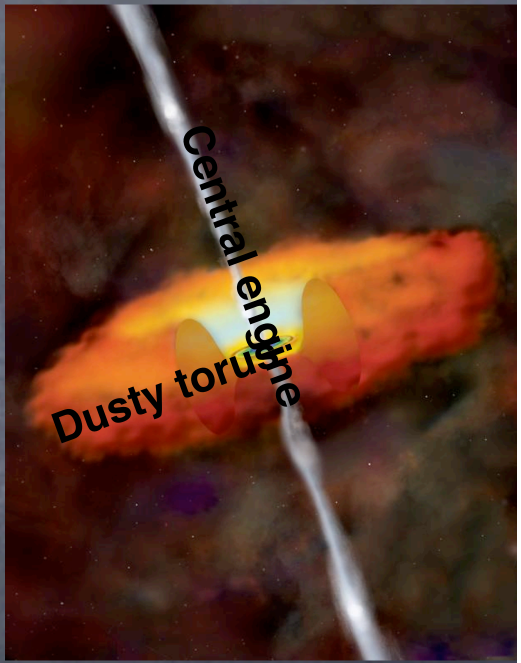
Unveiling obscured accretion: catching AGN feedback in action



Fabrizio Fiore

&

M. Brusa, A. Comastri, C. Feruglio, A. Fontana, A. Grazian, F. La Franca, N. Menci, E. Piconcelli, S. Puccetti, M. Salvato, P. Santini, C. Vignali, G. Zamorani
C-COSMOS & S-COSMOS teams

& many others

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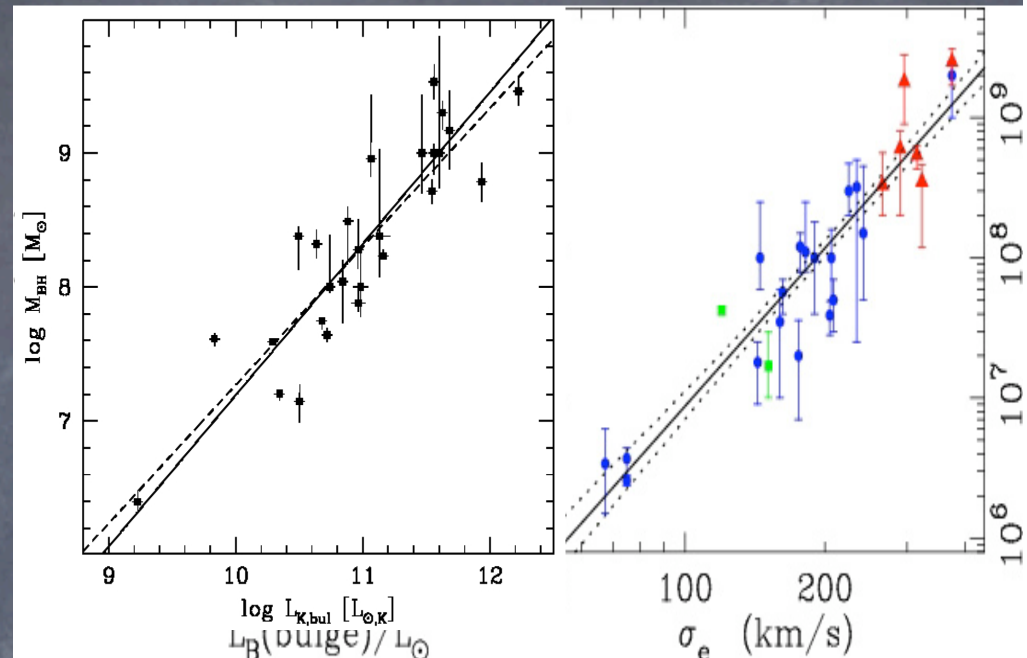
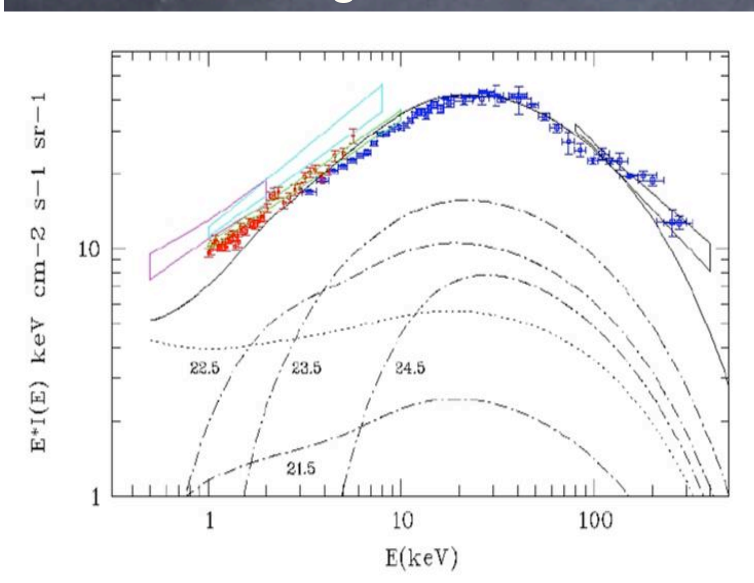
Co-evolution of galaxies and SMBH

Two seminal results:

1. The discovery of SMBH in the most local bulges; **tight correlation** between M_{BH} and bulge properties.
2. The BH mass density obtained integrating the AGN L.-F. and the CXB ~ that obtained from local bulges





⇒ **most BH mass accreted during luminous AGN phases!**

Most bulges passed a phase of activity:

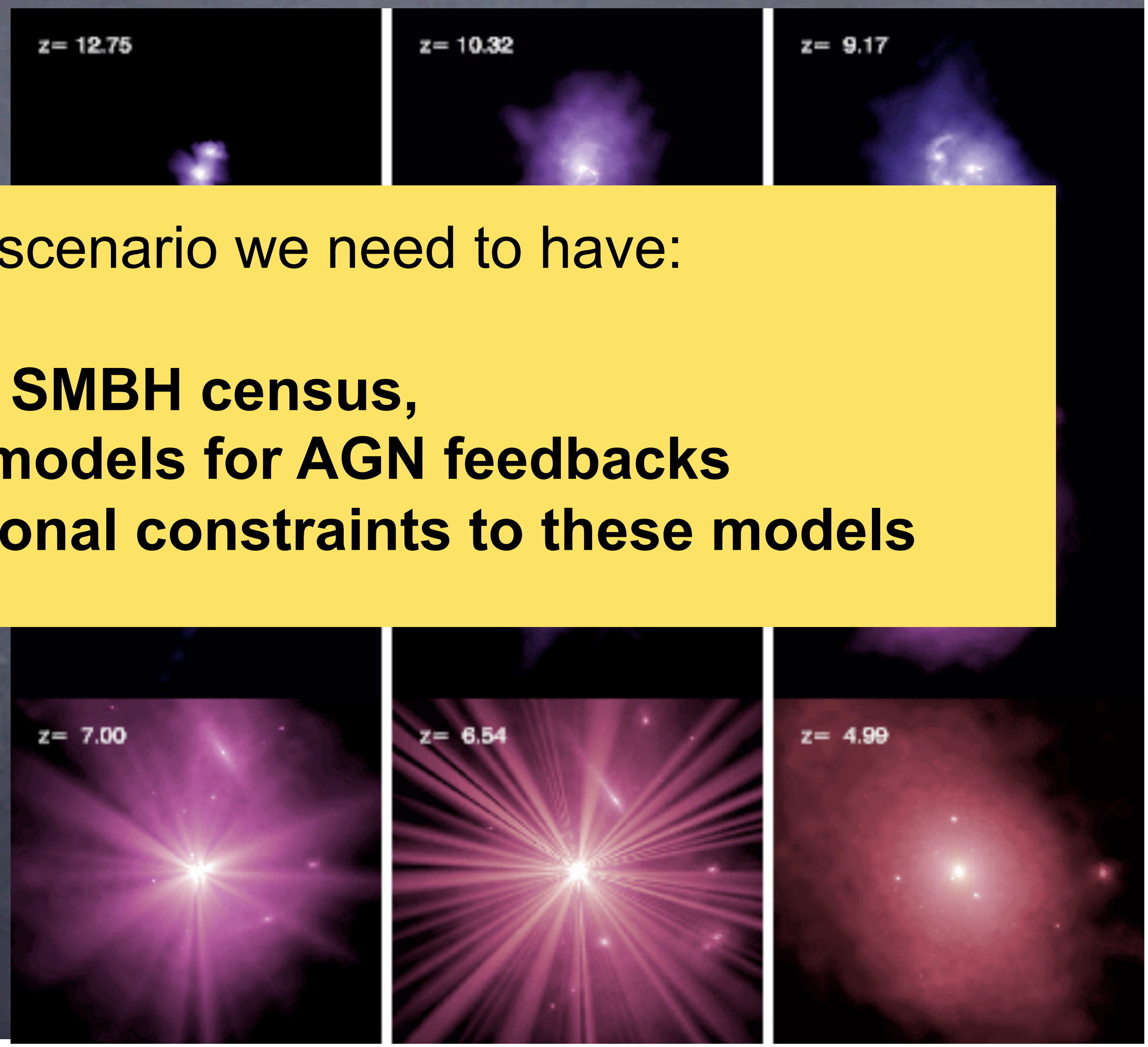
1) Complete SMBH census,

2) full understanding of AGN feedback

are key ingredients to understand galaxy evolution

AGN and galaxy co-evolution

- Early on
  - Strong galaxy interactions= violent star-bursts
  - Hea
    QSO
- When
  coales
  - accr
  - QSO
    opti
    AGN winds blow out gas.
- Later times
  - SF & accretion quenched
  - red spheroid, passive evolution

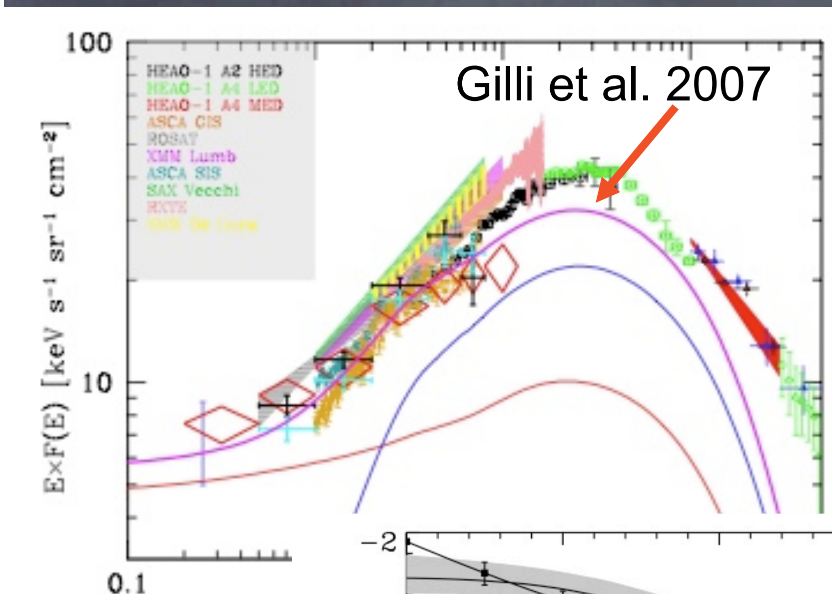


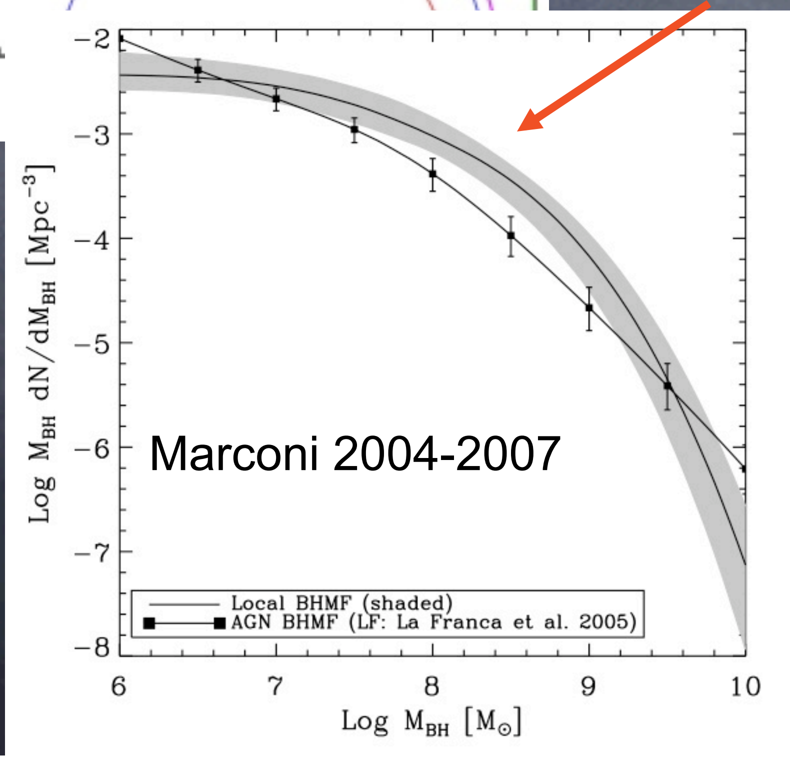
To prove this scenario we need to have:

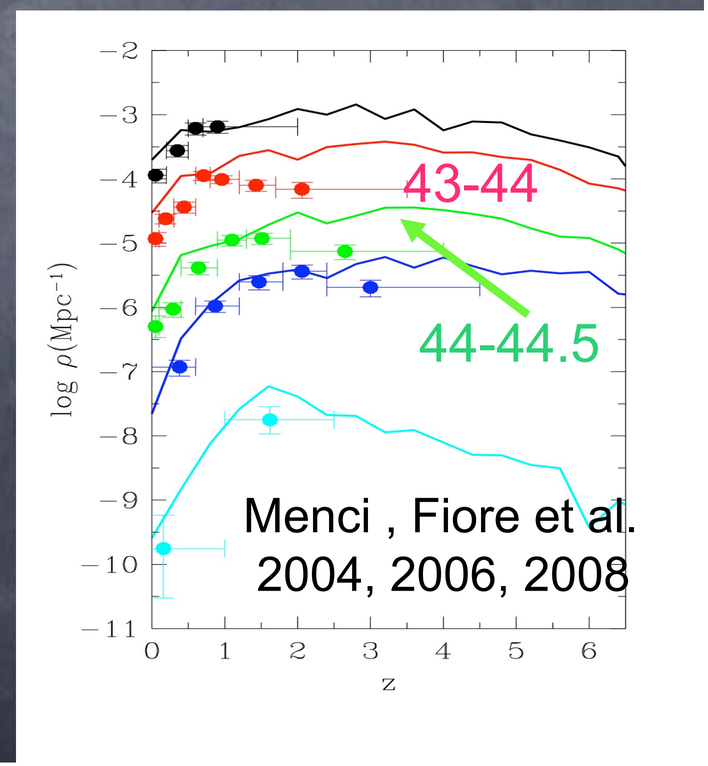
1) **Complete SMBH census,**
3) **Physical models for AGN feedbacks**
4) **Observational constraints to these models**

Evidences for missing SMBH

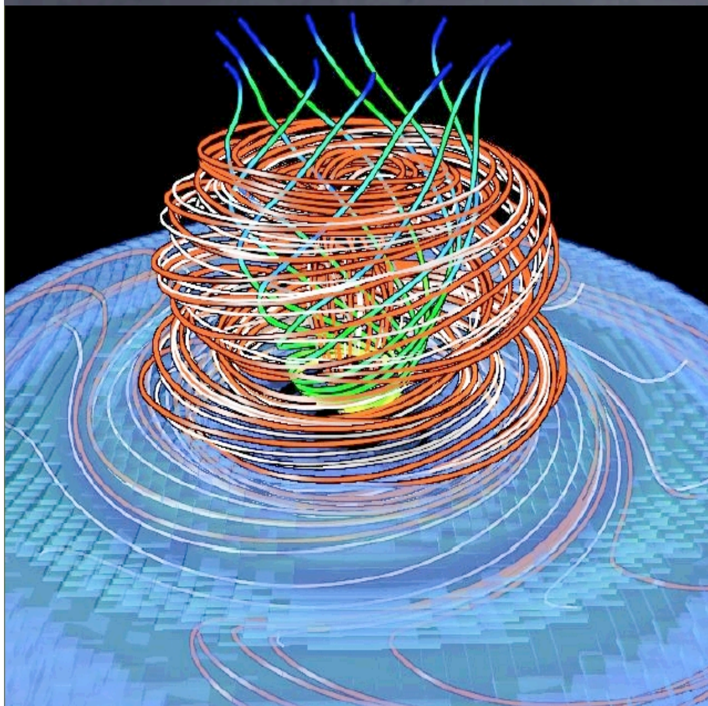
While the CXB energy density provides a statistical estimate of SMBH growth, the lack, so far, of focusing instrument above 10 keV (where the CXB energy density peaks), frustrates our effort to obtain a ***comprehensive picture of the SMBH evolutionary properties***.



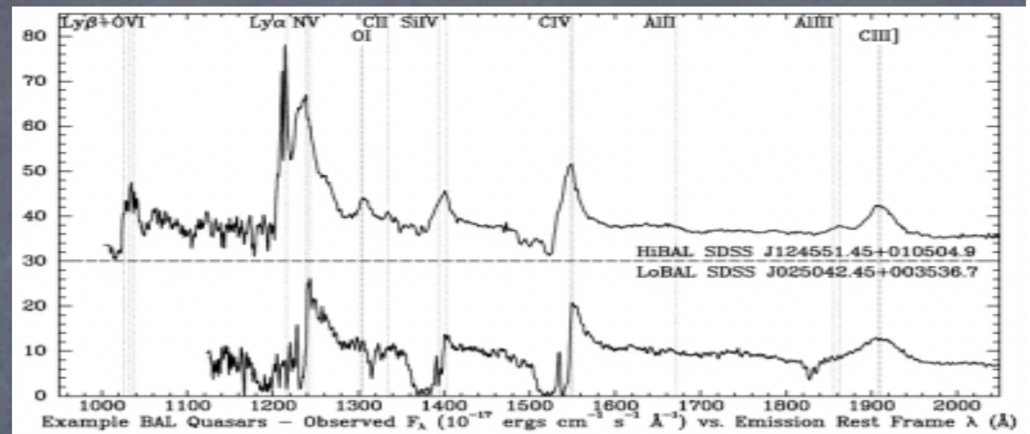




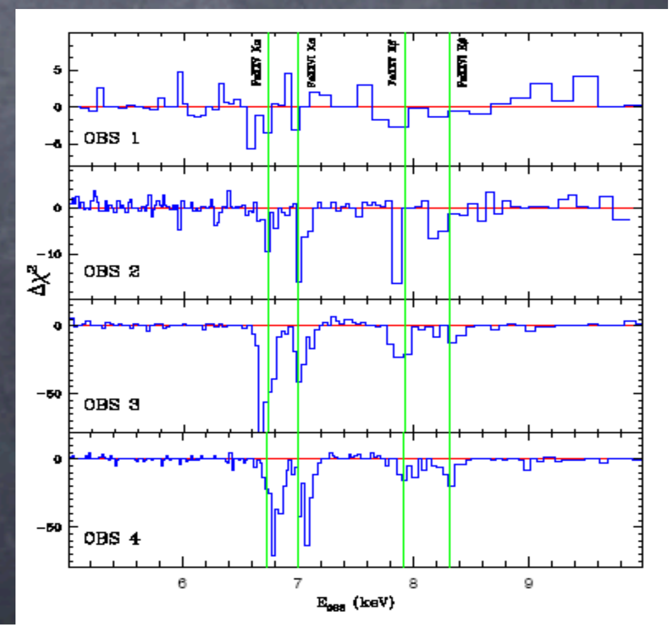
AGN feedback



BAL QSOs   (10-20% of all QSOs)



NGC1365 Risaliti et al. 2005



Fast winds with velocity up to a fraction of c are observed in the central regions of AGNs; they likely originate from the acceleration of disk outflows by the AGN radiation field

AGN feedback
(and AGN obscuration)

Lapi Cavaliere & Menci 2005 ***Blast wave model:*** a way to solve the problem of the transport of energy: central highly supersonic outflows compress the gas into a blast wave terminated by a shock front, which moves outwards at supersonic speed and sweeps out the surrounding medium

Measure of AGN obscuration can be an observational constraint of feedback models "in action"

$R_S(t) \propto Mt$

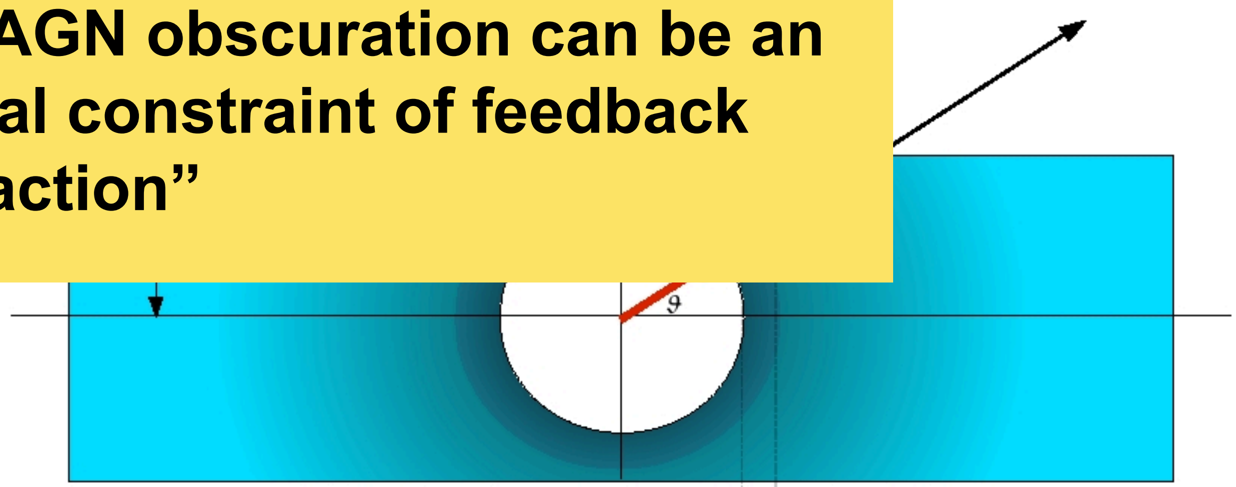
$M \sim \left(\frac{\Delta E}{E}\right)^{1/}$

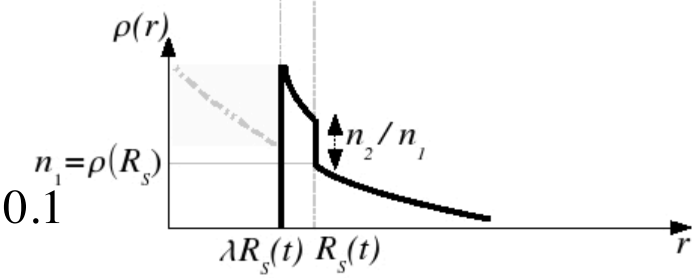
$\Delta E = \varepsilon L \tau$

$\varepsilon \sim \frac{v_w}{2c} \sim 0.05 \text{ if } v_w \sim 0.1$

$\tau =$ timescale of AGN activity $= \frac{\mathrm{r_d}}{\mathrm{v_d}} = 10^7 - 10^8\, yr$

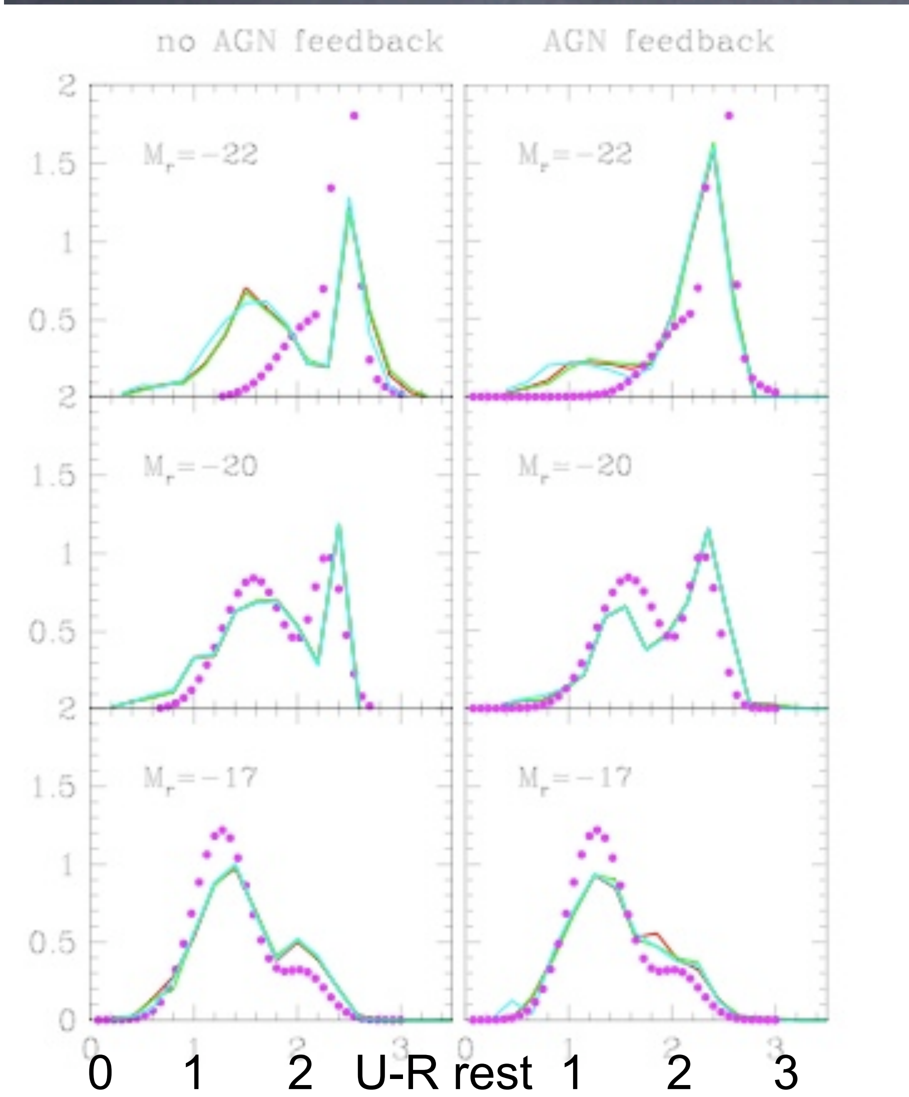
$L = \frac{\eta c^2 \Delta m_{acc}}{\tau}$ $\eta =$ efficiency of conv. of mass in rad. ~ 0.1

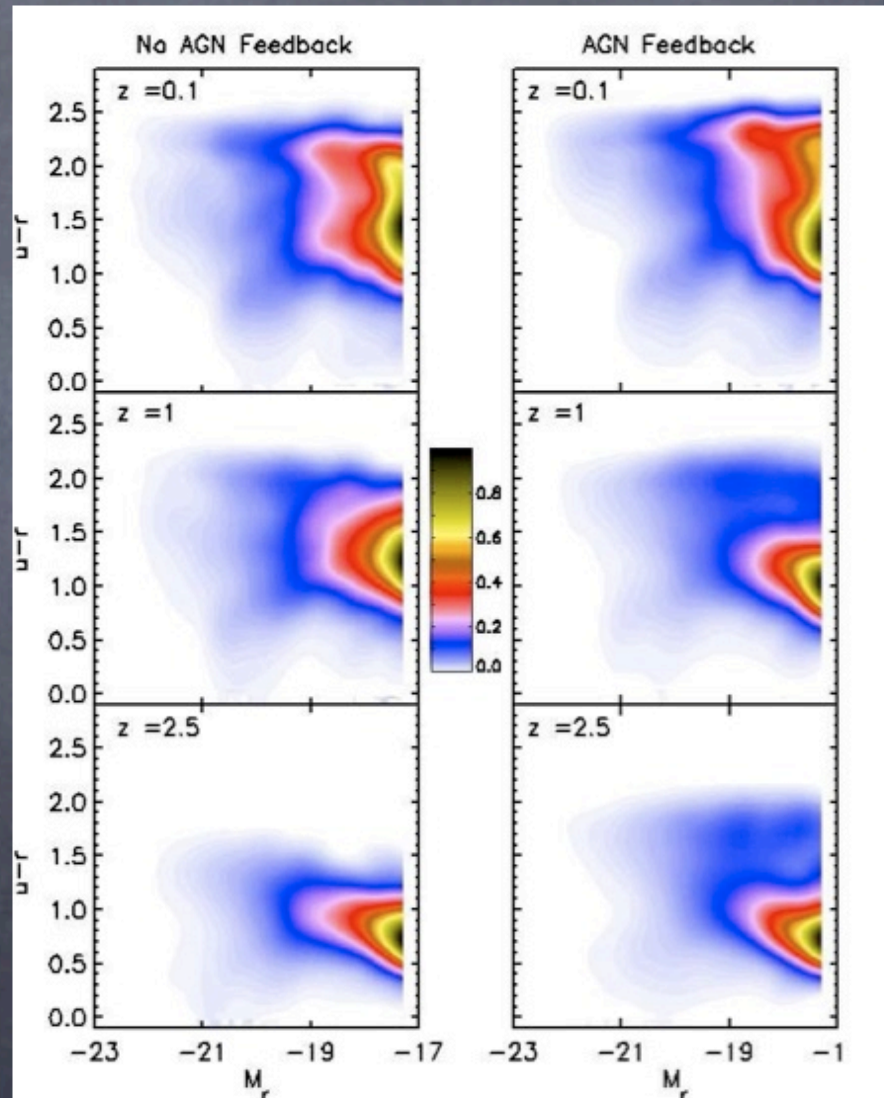




Results of AGN feedback: galaxy colors

Menci et al. 2006





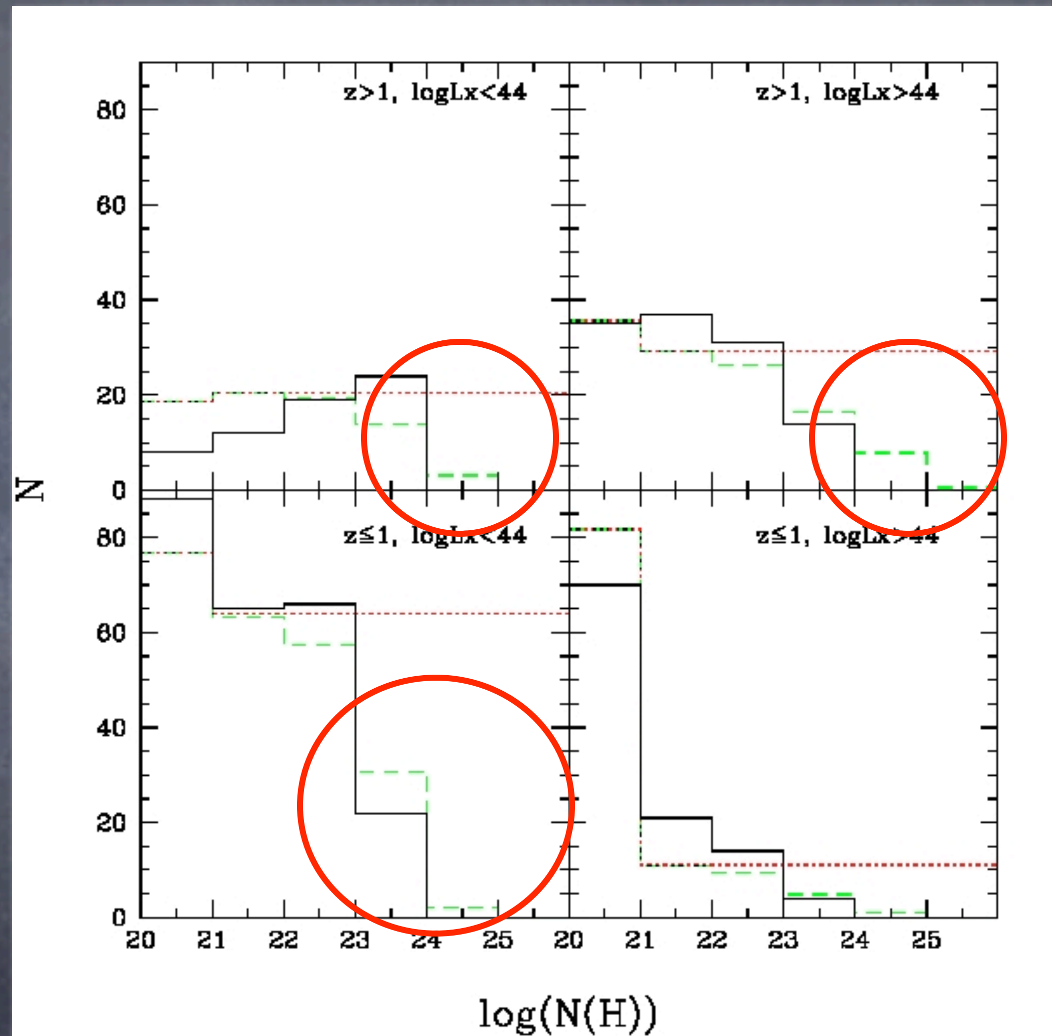
GOAL

- AGN Bolometric Luminosity function
  - Complete SMBH census
- Evolution of the fraction of obscured AGN
  - Probe feedback mechanisms *“in action”*

- Strong constraints to models for the formation and evolution of structure in the Universe

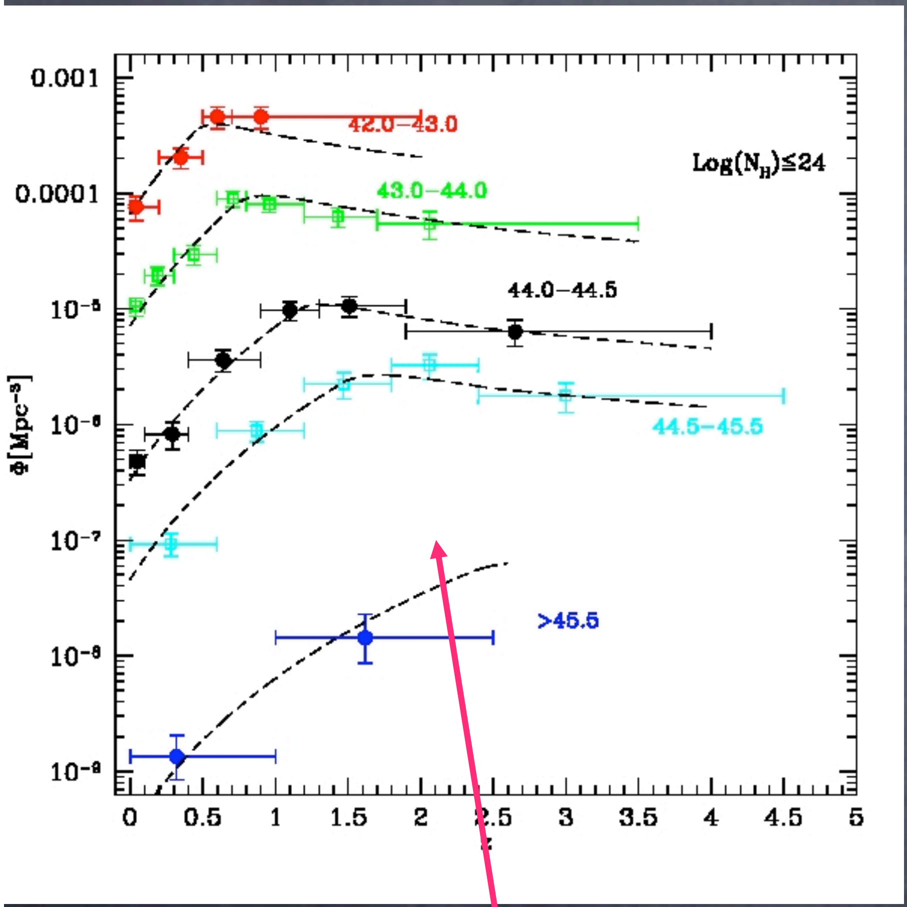
Why multiwavelength surveys

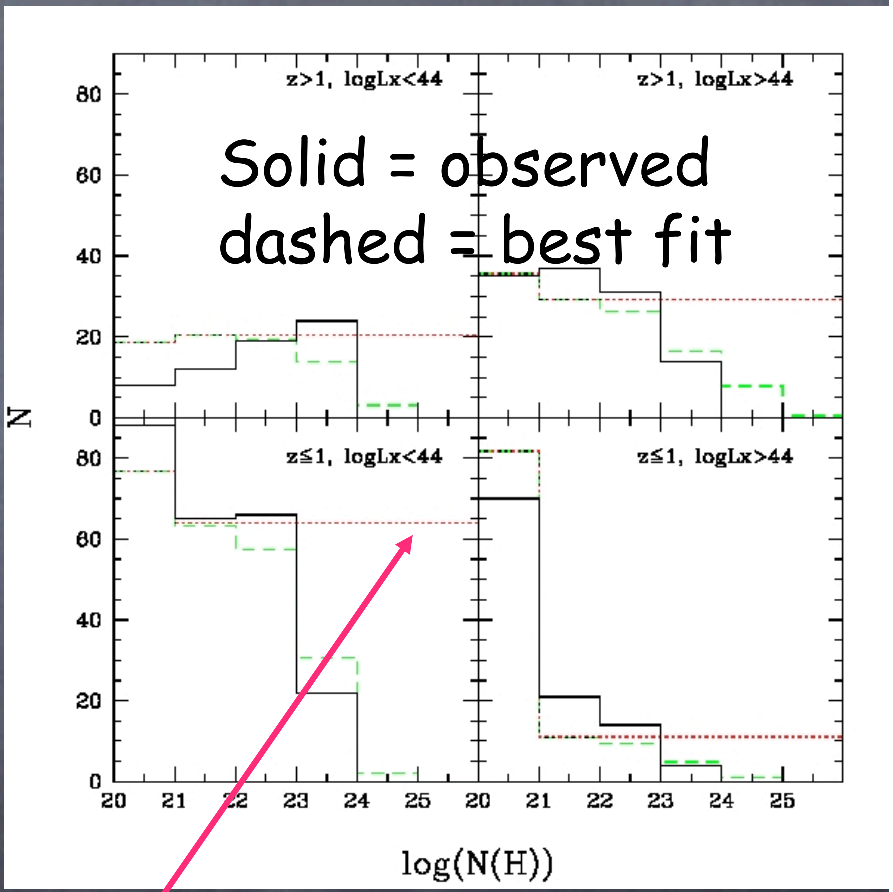
- X-ray surveys:
- very efficient in selecting unobscured and moderately obscured AGN
- Miss most highly obscured AGN



La Franca et al. 2005

2-10 keV AGN luminosity function models

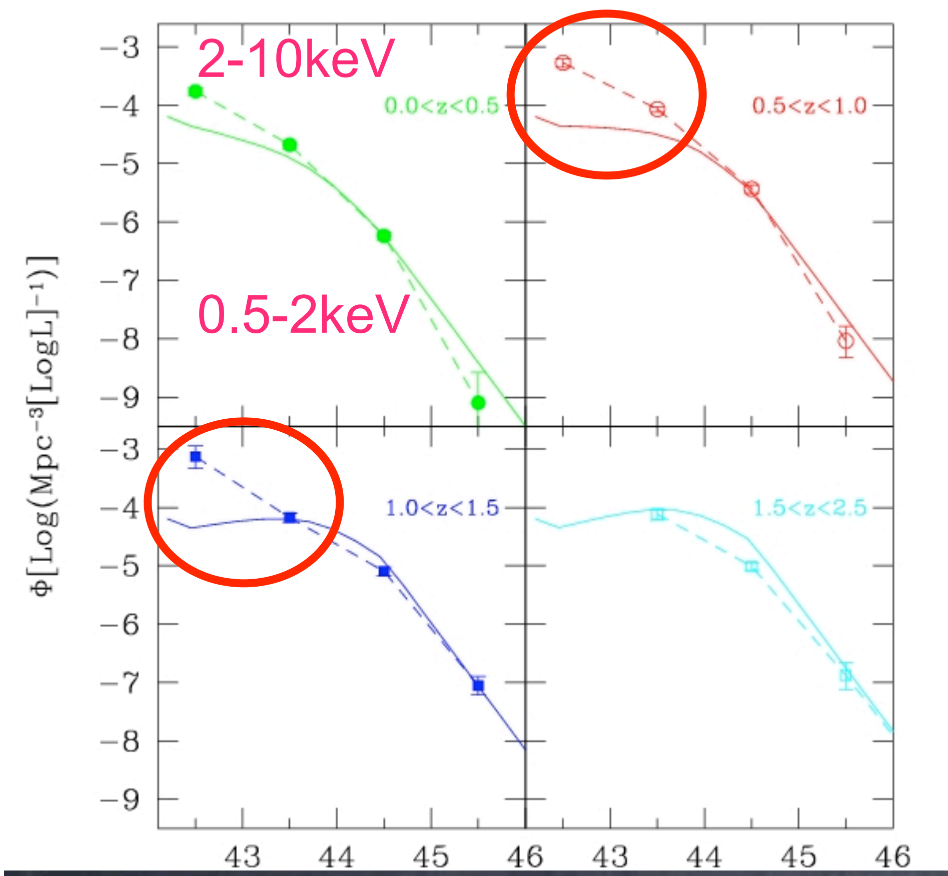


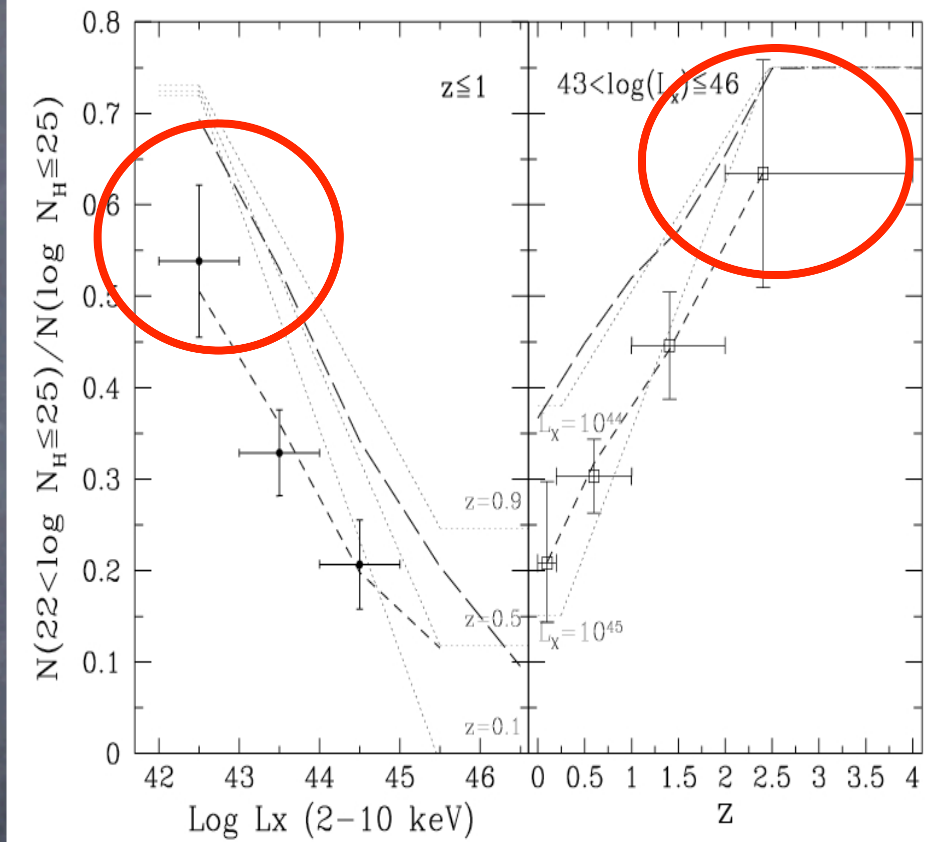


LDDE with constant N_H distribution

La Franca et al. 2005

2-10 keV AGN luminosity function models



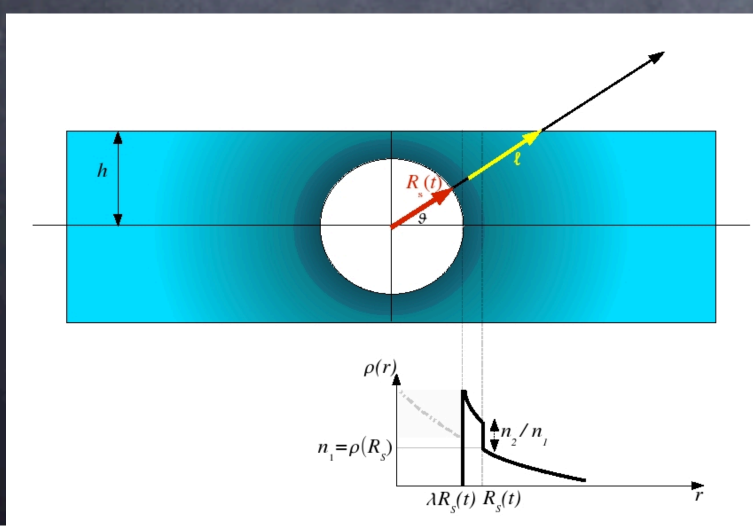


LDDE with variable absorbed AGN fraction

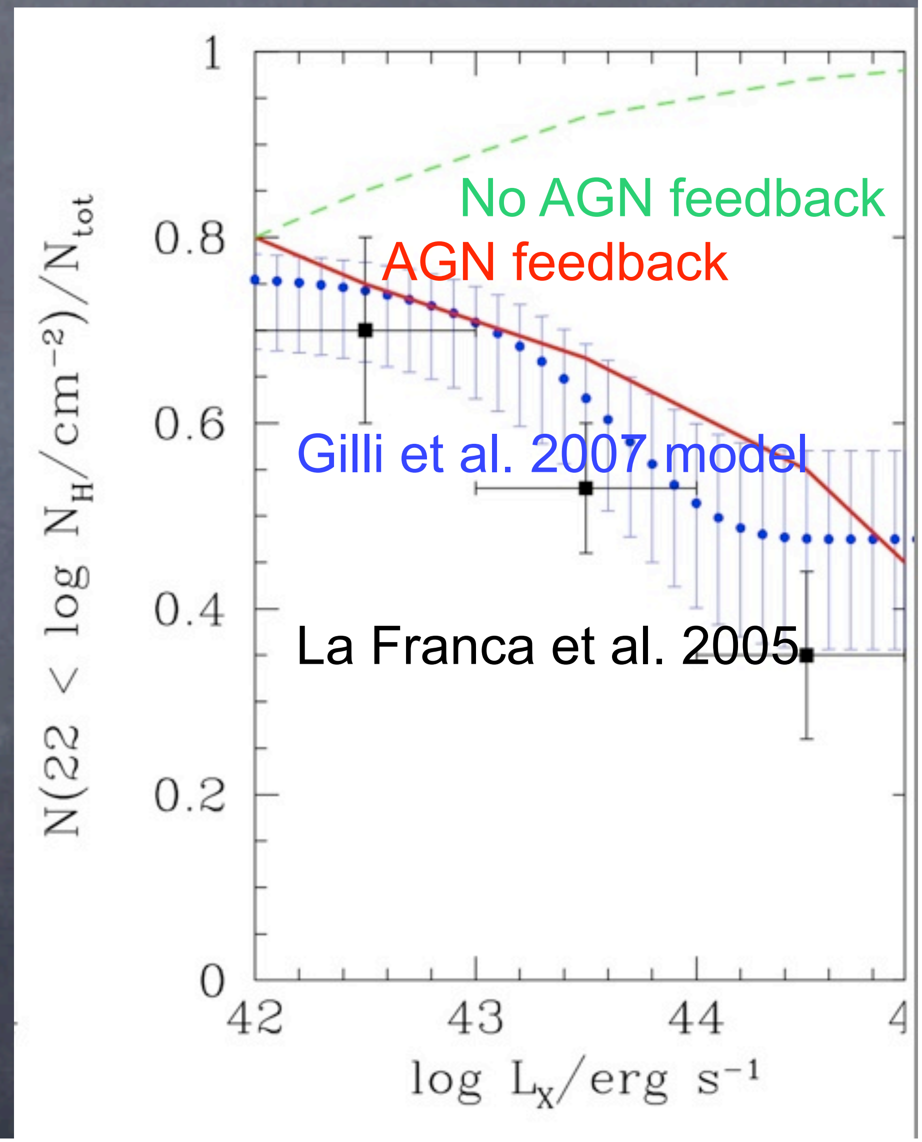
La Franca et al. 2005

Fraction of obscured AGN

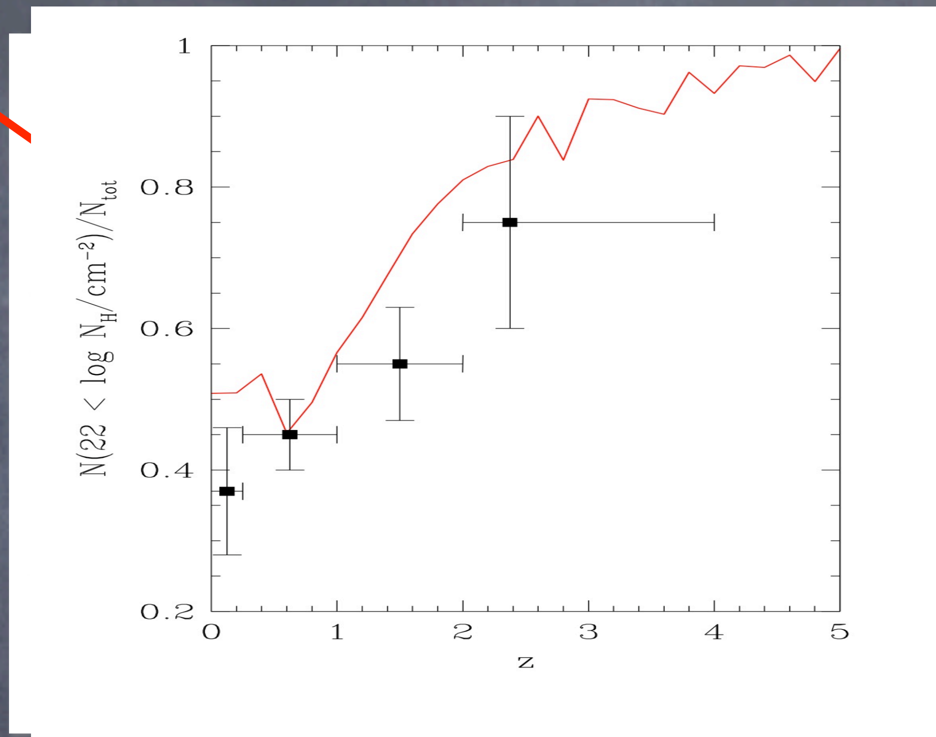
Powerful AGN clean their sight-lines more rapidly than low luminosity AGN, and therefore the fraction of obscured AGN can be viewed as a ***measure of the timescale over which the nuclear feedback is at work.***



Menci, Fiore et al. 2008



A working scenario



small mass progenitors. Feedback is effective in self-regulating accretion and SF, cold gas is left available

Galactic cold gas available for accretion and obscuration increases at high z

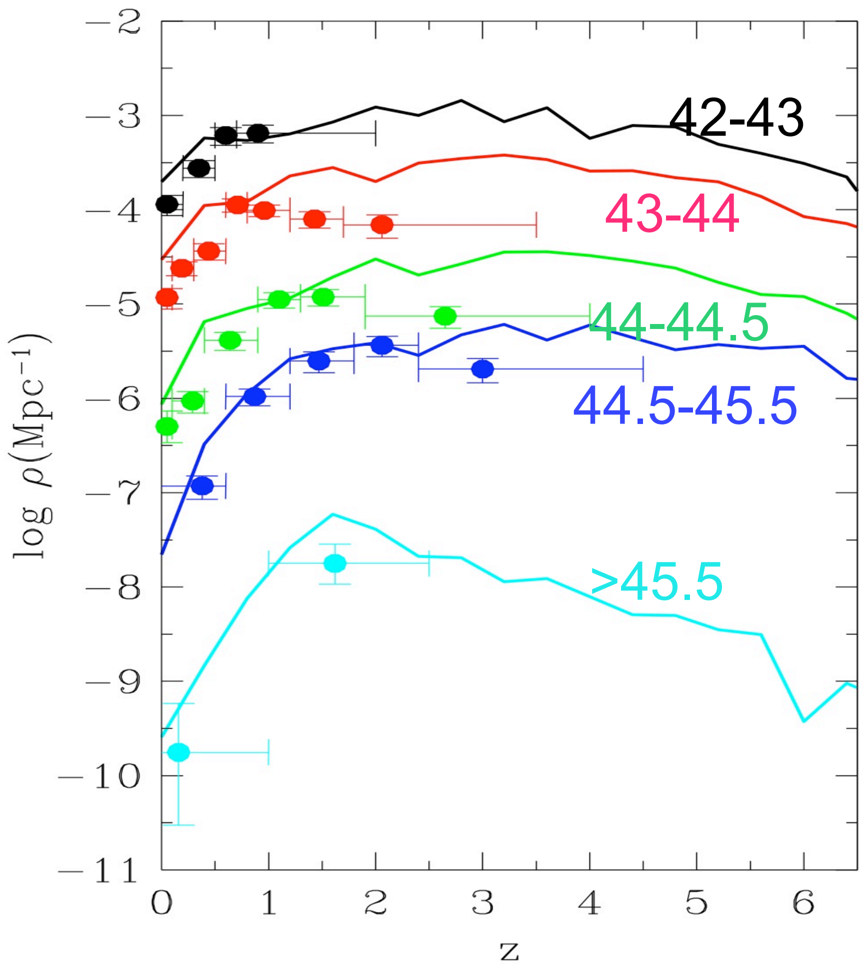
large mass progenitors. Feedback is faster. Most gas is quickly converted in stars at high z, AGN blows out the remaining.

Menci hierarchical clustering model,

Menci, Fiore, Puccetti, Cavaliere 2008

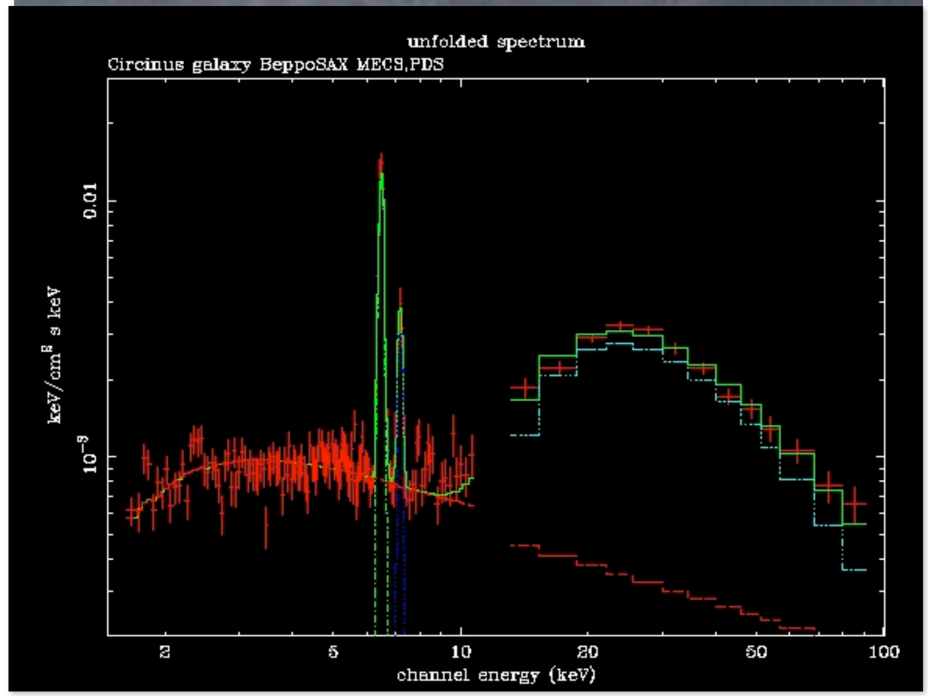
AGN density

La Franca, Fiore et al. 2005
Menci, Fiore et al. 2008



Paucity of Seyfert like sources @ z>1 is real? Or, is it, at least partly, a selection effect?

Are we missing in Chandra and XMM surveys highly obscured ($N_H \times 10^{24}$ cm^{-2}) AGN? Which are common in the local Universe…



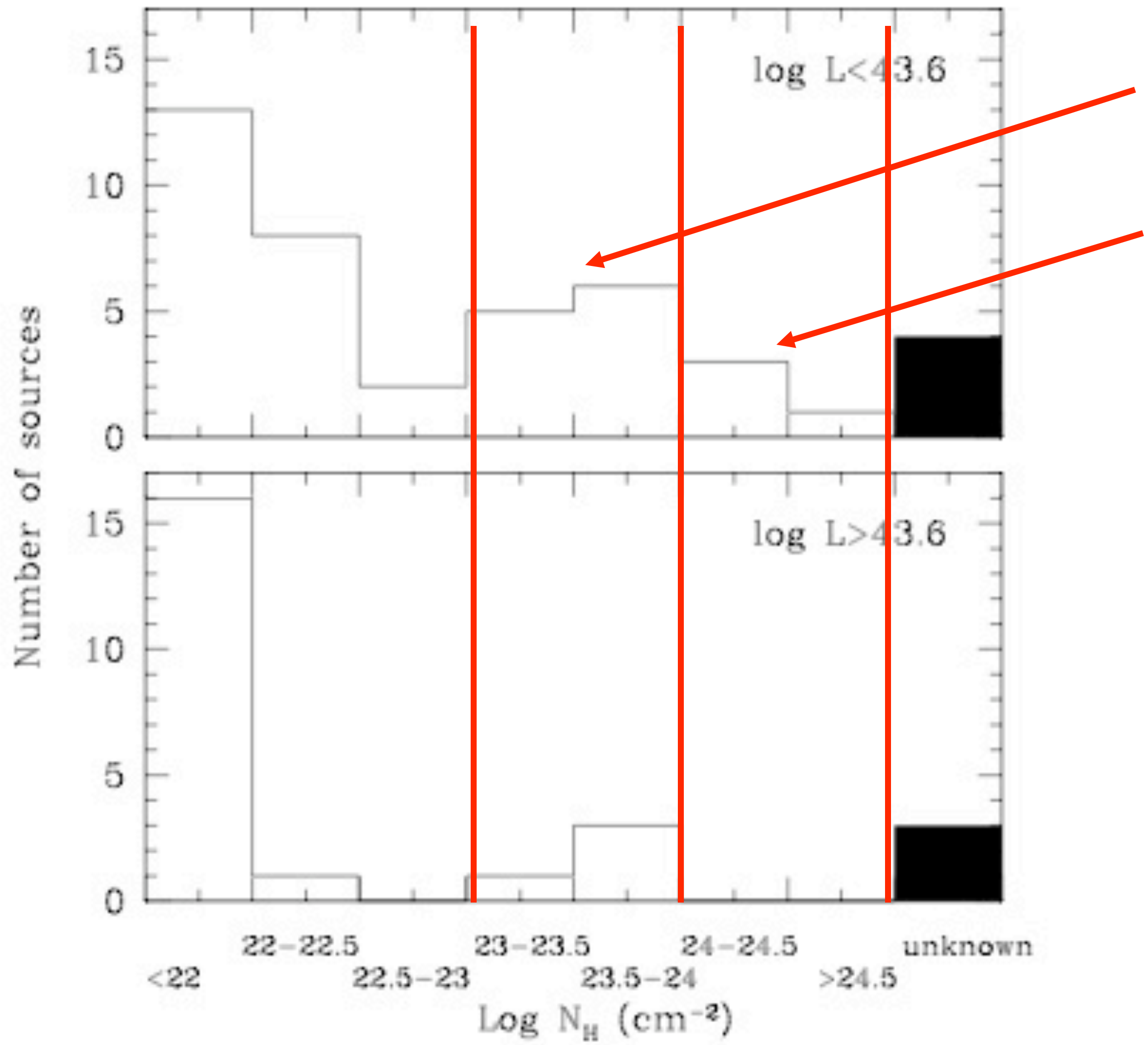


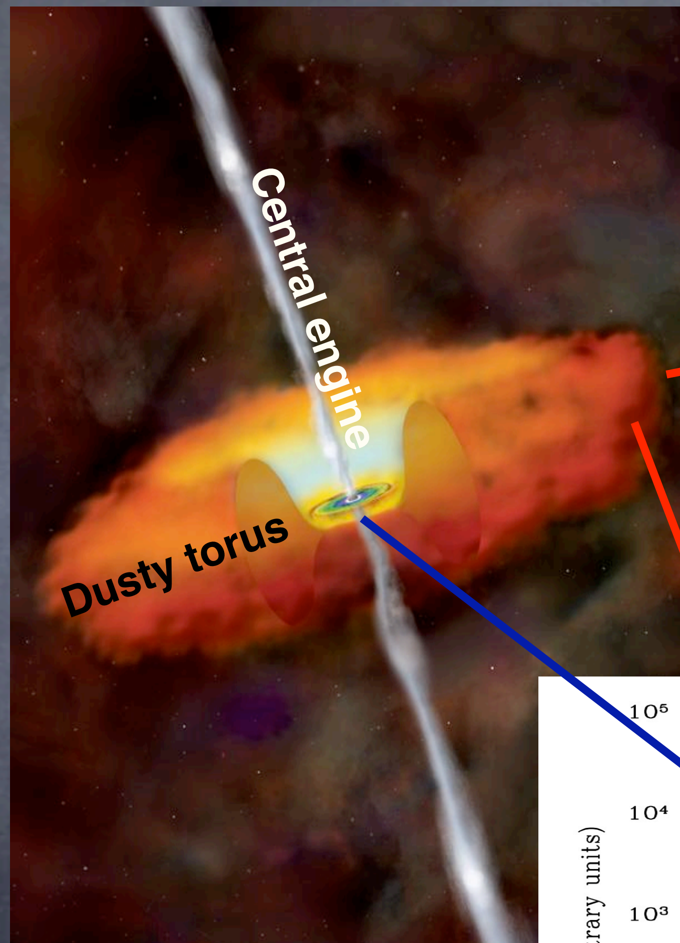
Fig. 2. Observed X-ray absorption distribution of the low-luminosity AGN (top panel), and high-luminosity AGN (bottom panel). The shaded part of each diagram shows the number of AGN with unknown N_H.

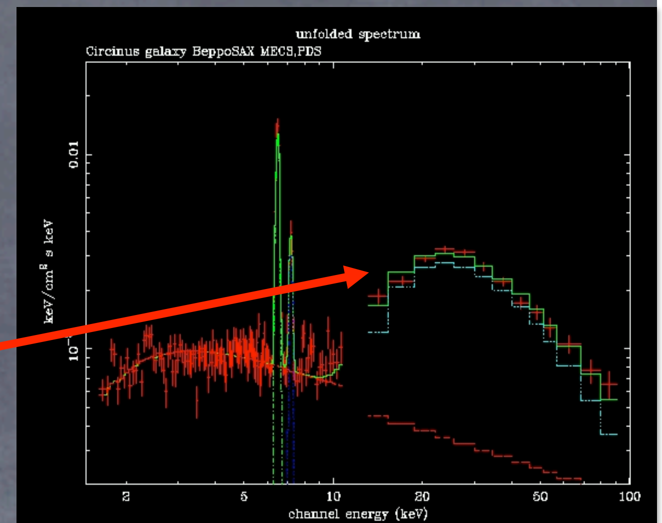
INTEGRAL survey
~ 100 AGN

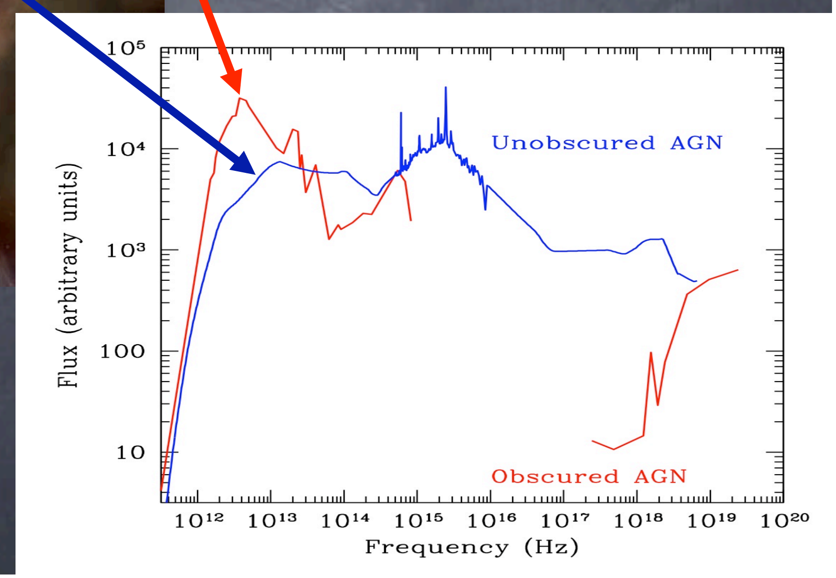
Sazonov et al. 2006

Why multiwavelength surveys

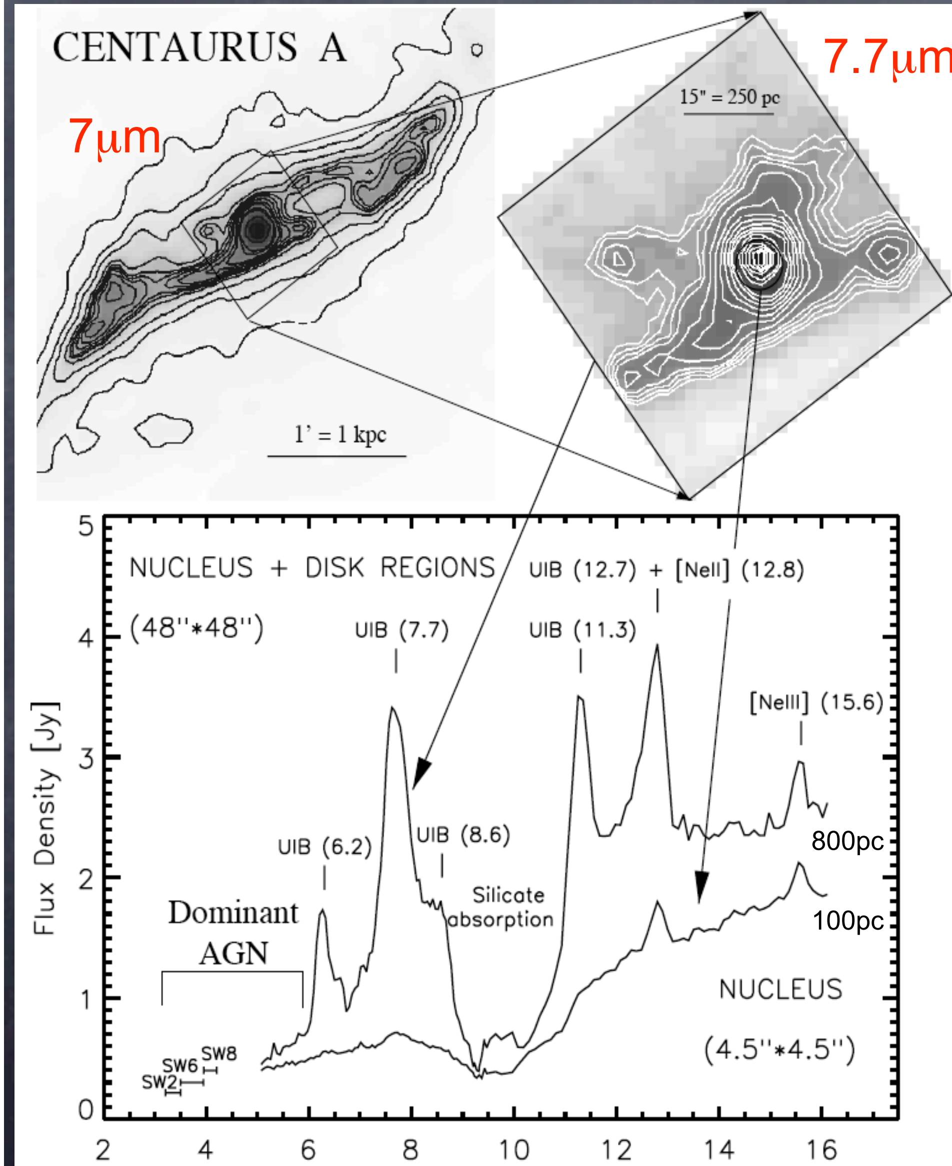
- IR surveys:
- AGNs highly obscured at optical and X-ray wavelengths shine in the MIR thanks to the reprocessing of the nuclear radiation by dust





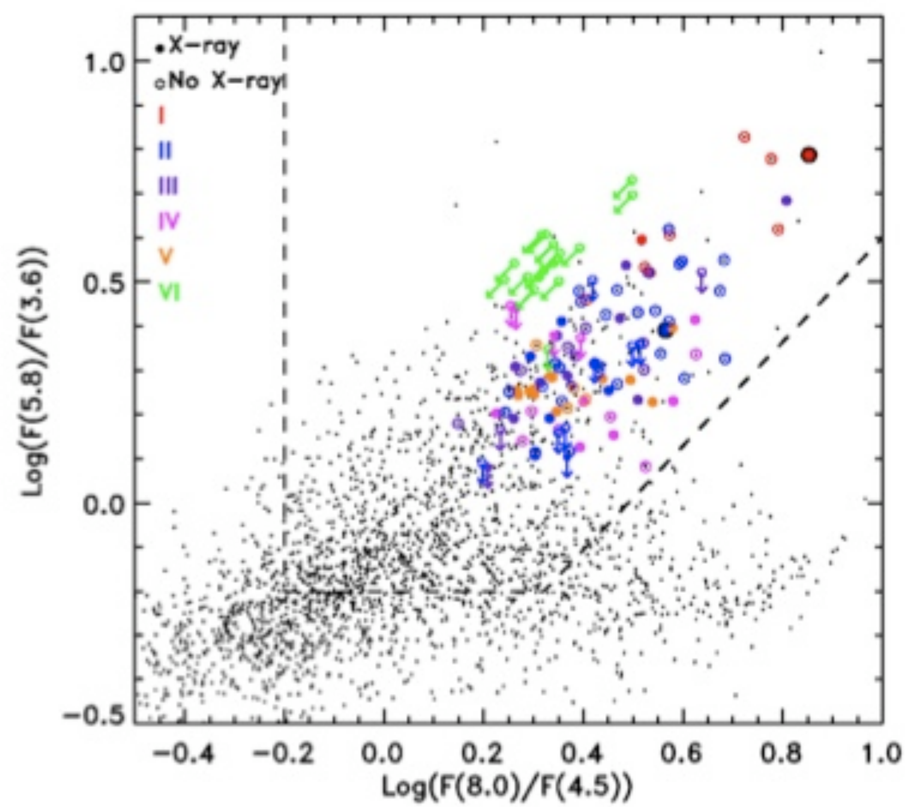


IR surveys



Laurent et al. 01

- Difficult to isolate AGN from star-forming galaxies (Lacy 2004, Barnby 2005, Stern 2005, Polletta 2006 and many others)



Why multiwavelength surveys

- Use both X-ray and MIR surveys:

- Select unobscured and moderately obscured AGN in X-rays
- Add highly obscured AGNs selected in the MIR

- Simple approach: Differences are emphasized in a wide-band SED analysis

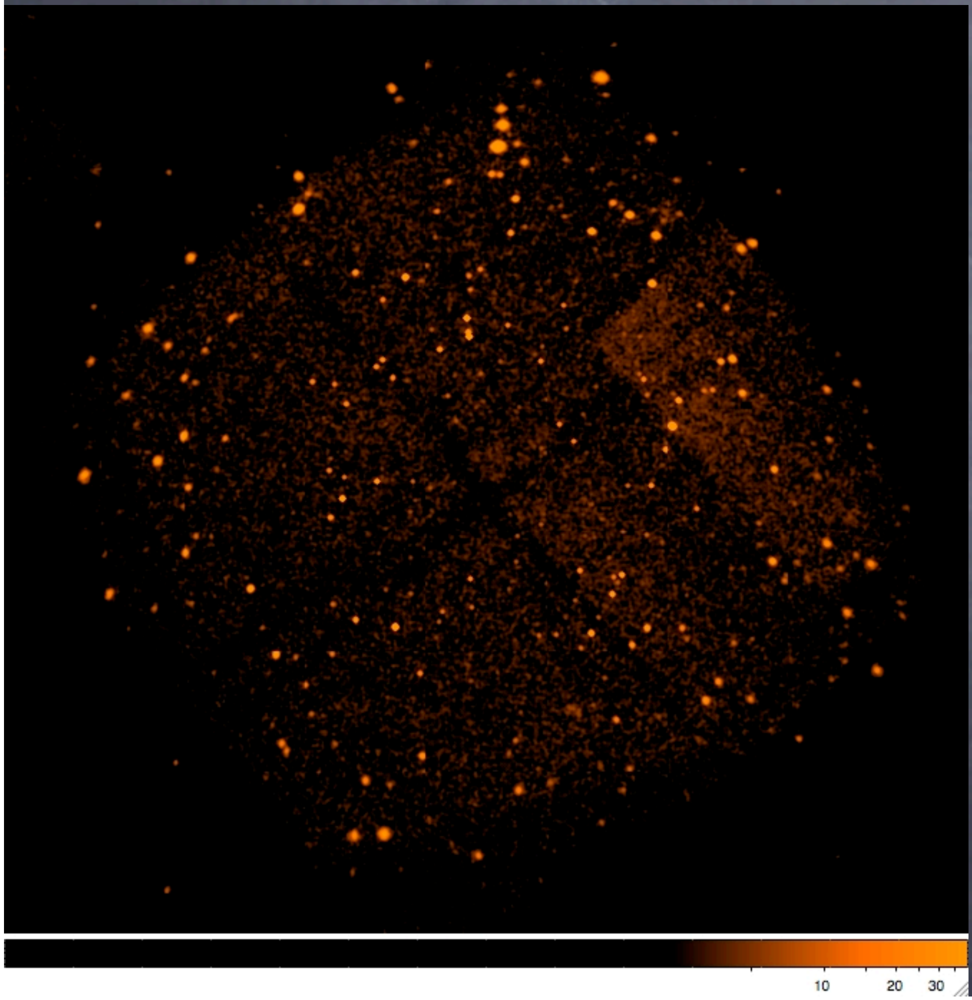
X-ray-MIR surveys

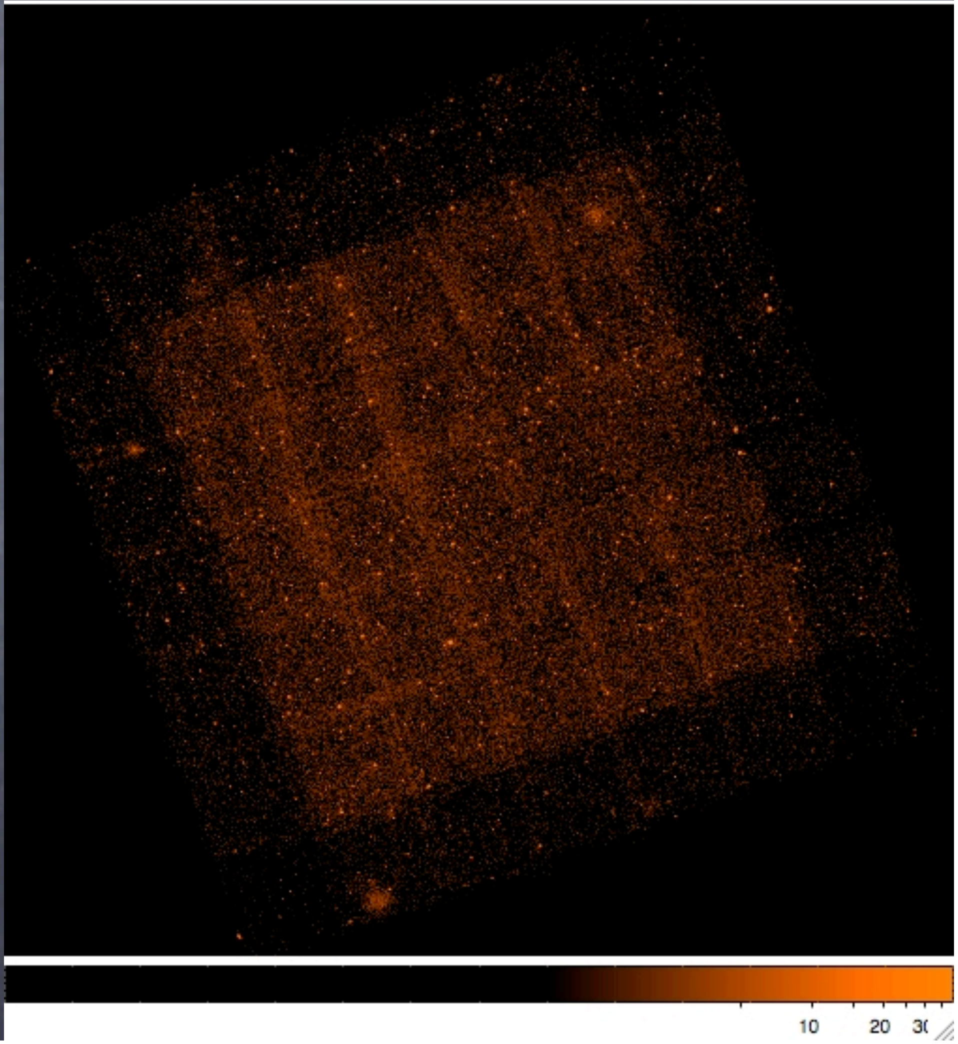
- CDFS-Goods MUSIC catalog (Grazian et al. 2006, Brusa, FF et al. 2008) Area 0.04 deg2
- 173 X-ray sources, 104 2-10 keV down to 3×10^{-16} cgs, 109 spectroscopic redshifts
- 1700 MIPS sources down to 40 μJy, 3.6μm detection down to 0.08 μJy
- Ultradeep Optical/NIR photometry, R~27.5, K~24
- ELAIS-S1 SWIRE/XMM/Chandra survey (Puccetti, FF et al. 2006, Feruglio,FF et al. 2007, La Franca, FF et al. 2008). Area 0.5 deg2
- 500 XMM sources, 205 2-10 keV down to 3×10^{-15} cgs, >half with spectroscopic redshifts.
- 2600 MIPS sources down to 100 μJy, 3.6μm detection down to 6 μJy
- Relatively deep Optical/NIR photometry, R~25, K~19
- COSMOS XMM/Chandra/Spitzer. Area ~1 deg^2
- ~1700 Chandra sources down to 6×10^{-16} cgs, >half with spectroscopic redshifts.
- 900 MIPS sources down to 500 μJy, 3.6μm detection down to 10 μJy, R~26.5
- In future we will add:
- CDFS-Goods, Chandra 2Msec observation
- CDFN-Goods
- COSMOS deep MIPS survey

Chandra deep and wide fields

CDFS 2Msec 0.05deg^2
~400 sources

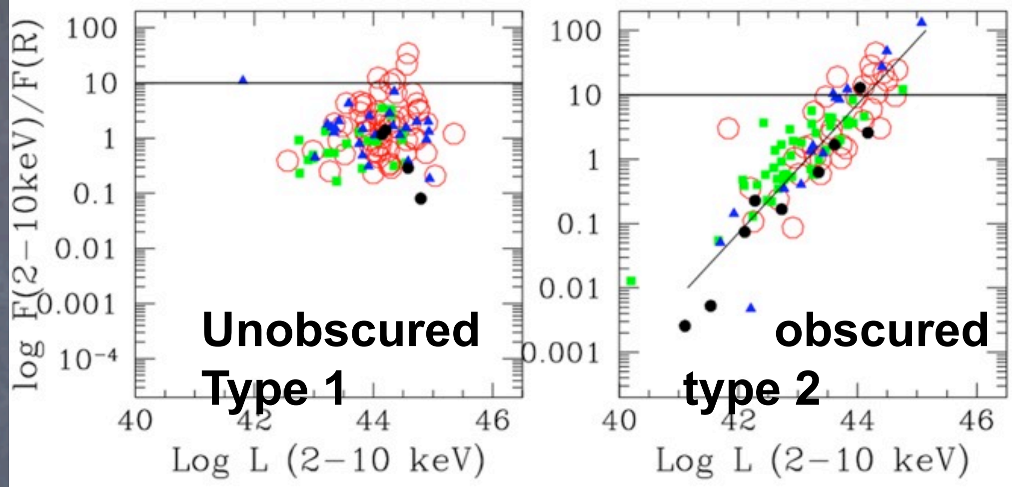
CCOSMOS 200ksec 0.5deg^2 100ksec 0.4deg^2
1.8 Msec ~1800 sources



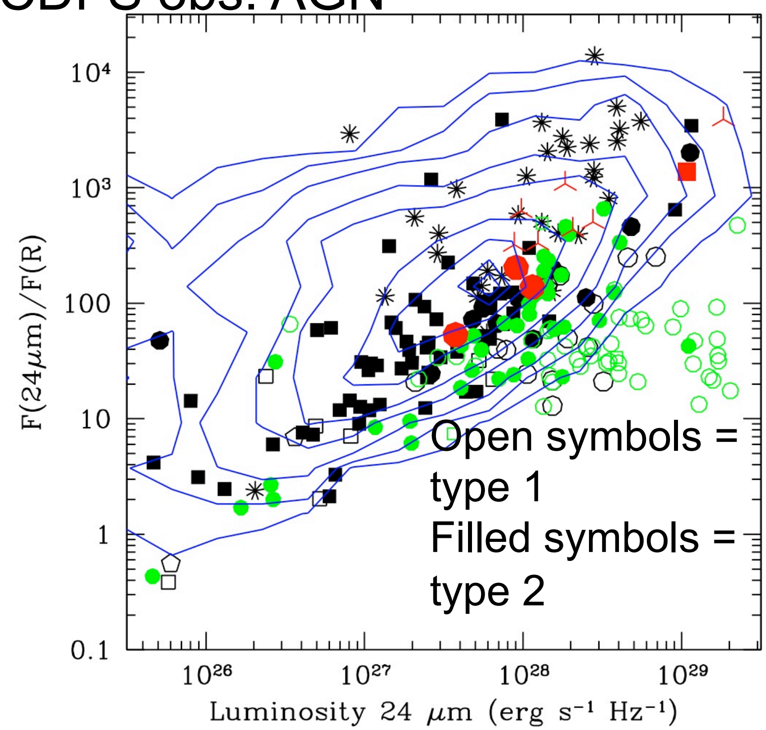


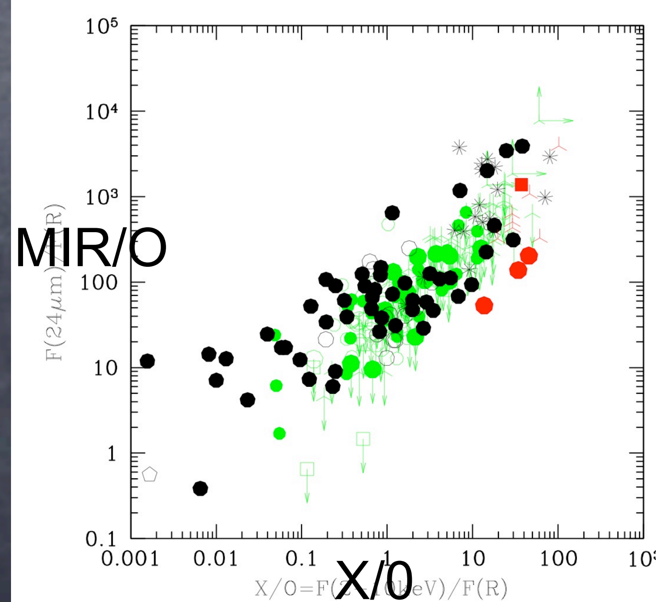
MIR selection of CT AGN

Fiore et al. 2003



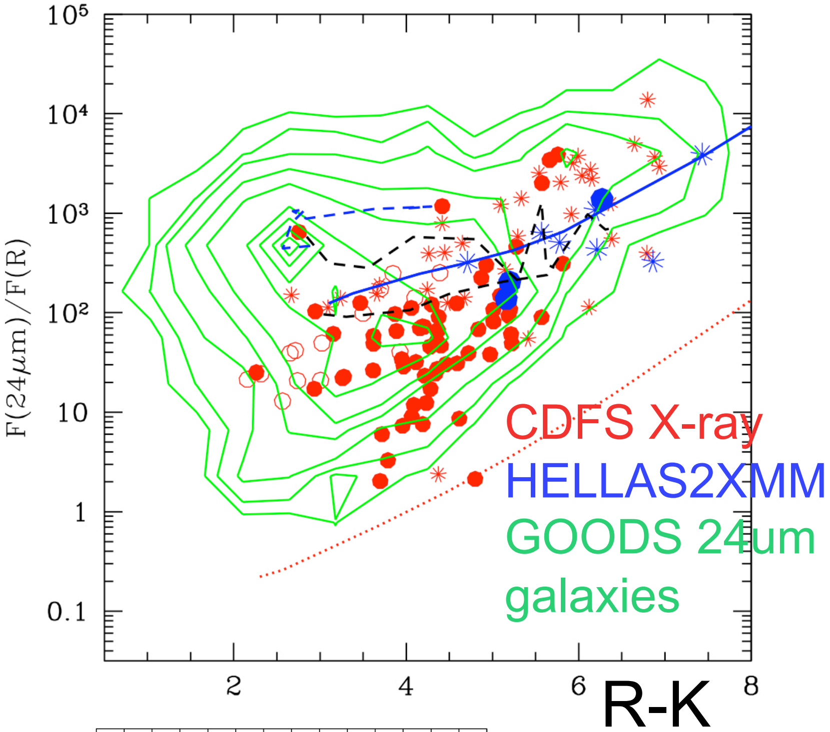
ELAIS-S1 obs. AGN
ELAIS-S1 24mm galaxies
HELLAS2XMM
CDFS obs. AGN



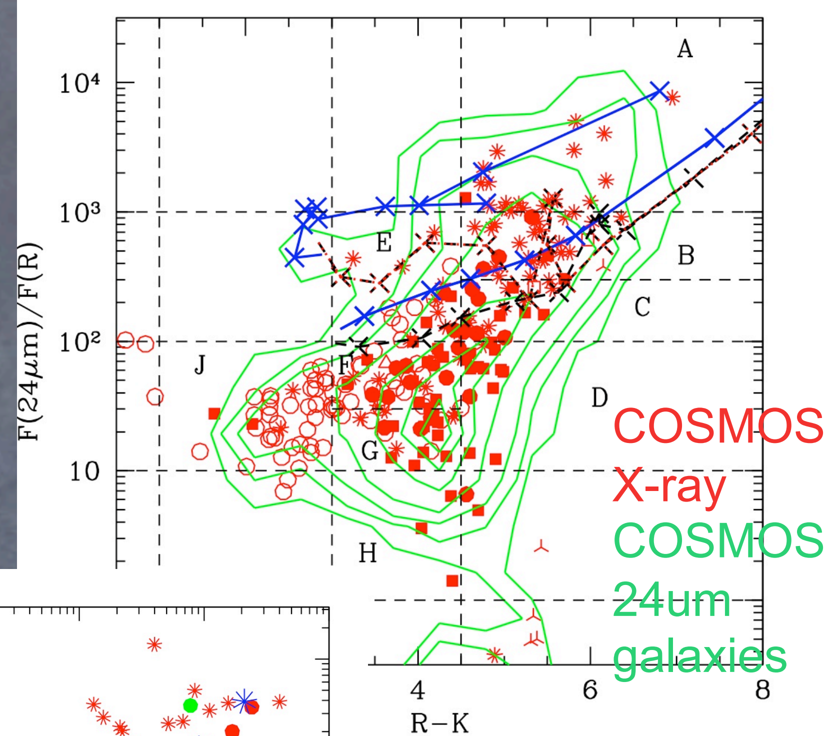


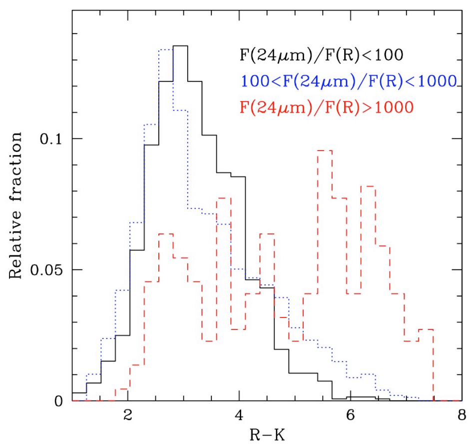
MIR selection of CT AGN

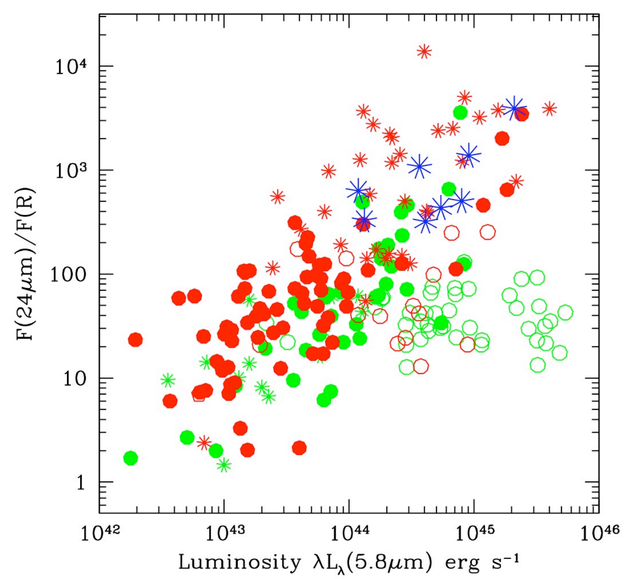
Fiore et al. 2008a



Fiore et al. 2008b

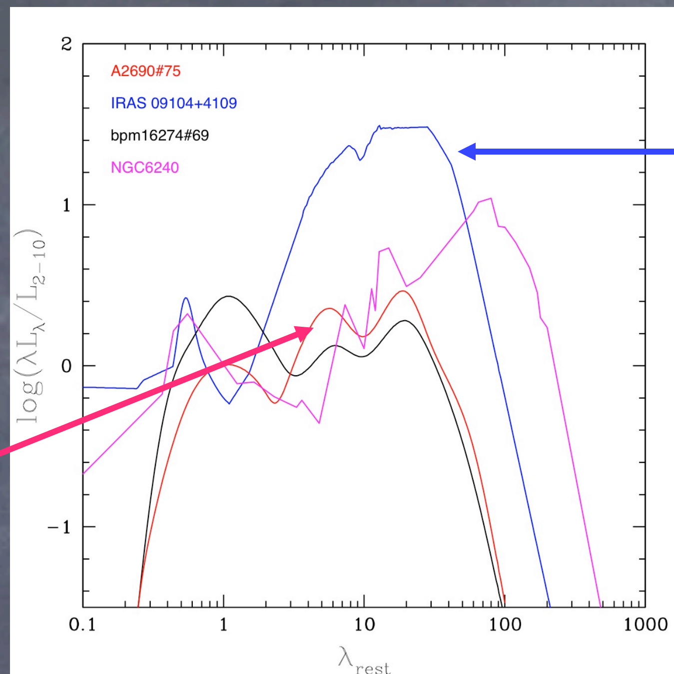






Open symbols = unobscured AGN
Filled symbols = optically obscured AGN

Template highly obscured QSOs



- IRAS09104+4109
- High L(IR)/Lx ratio
- No PAH emission features in IRS spectrum
- IR SED dominated by the AGN

Abel2690#75

(Pozzi et al 2007)

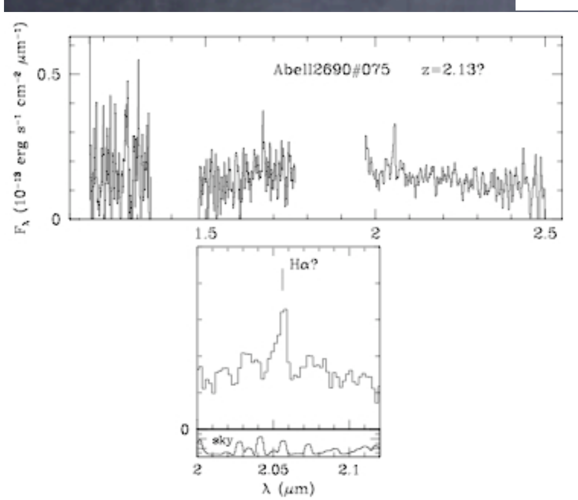
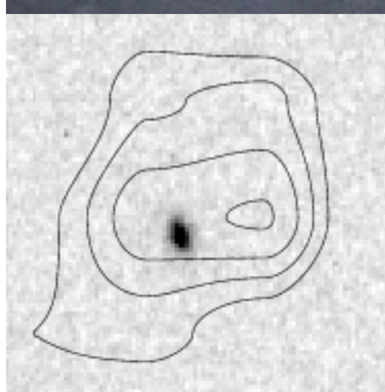
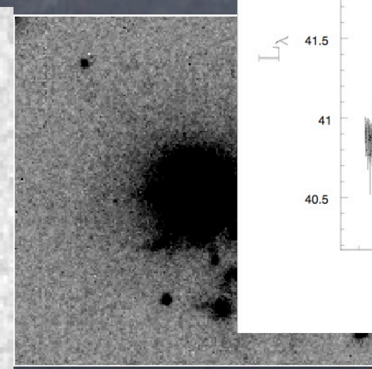
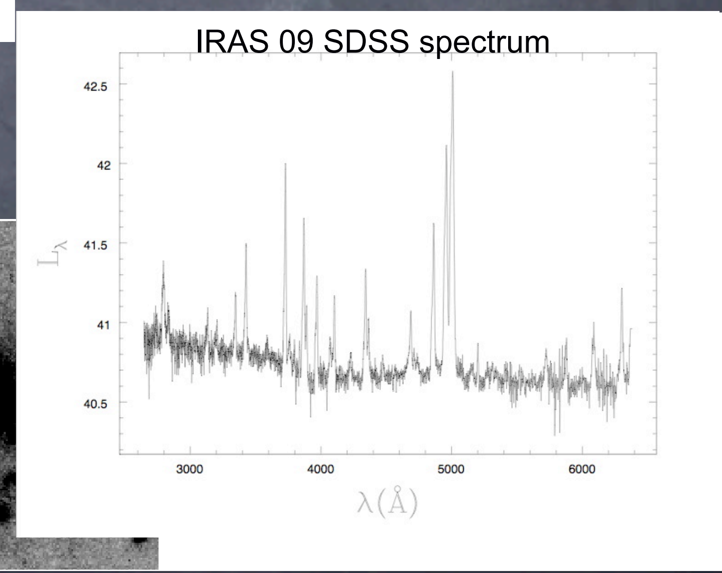


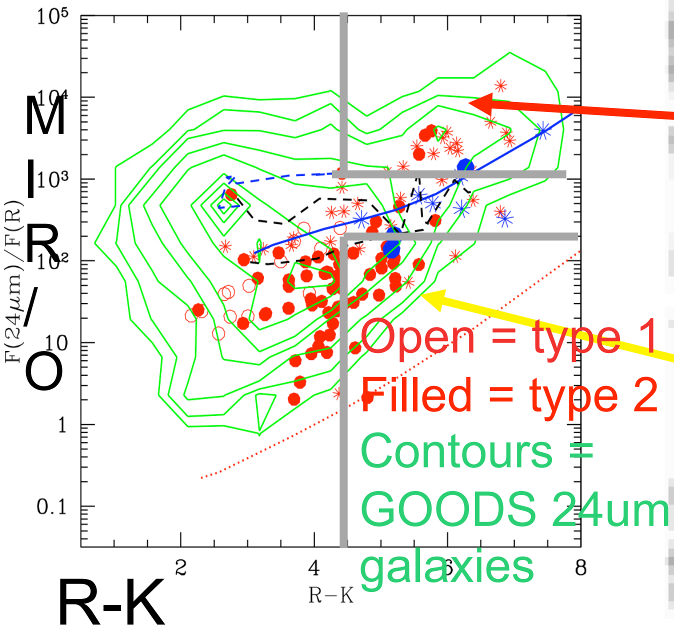
Fig. 4. As Fig.2 for Abell2690#075. The bottom panel shows the zoom around a line tentatively identified as Hα at z=2.13.

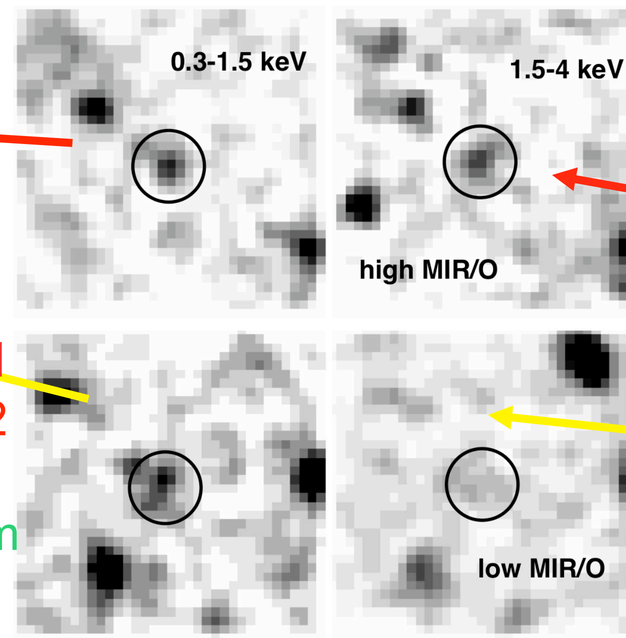


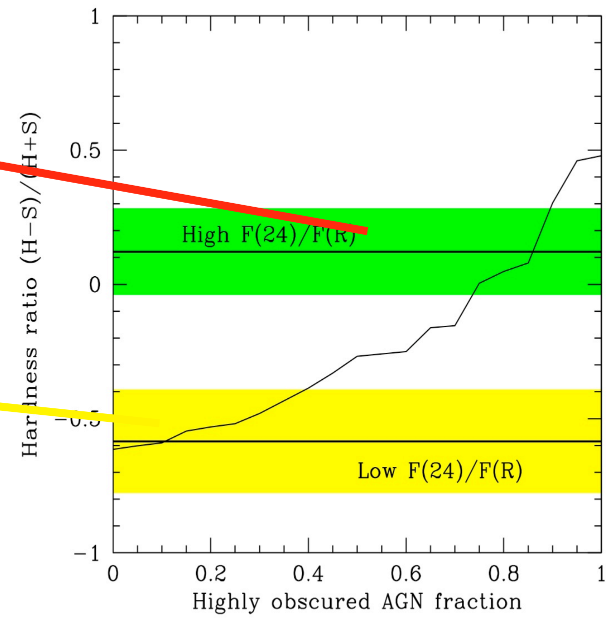


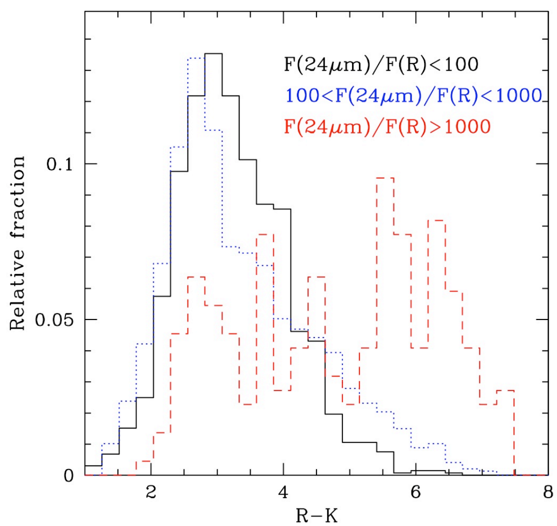


GOODS MIR AGNs









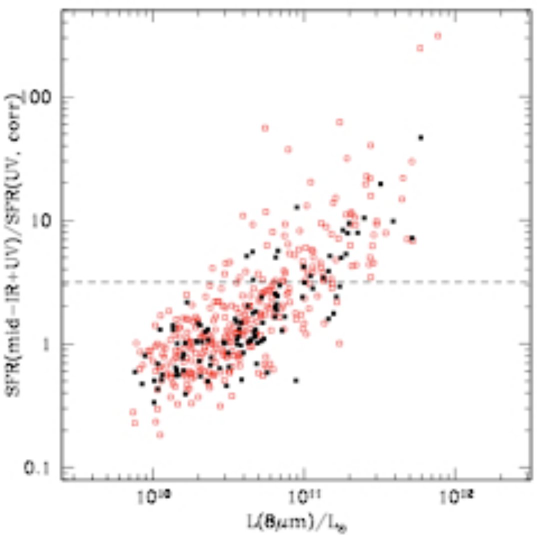
Stack of Chandra images of MIR sources not **directly** detected in X-rays

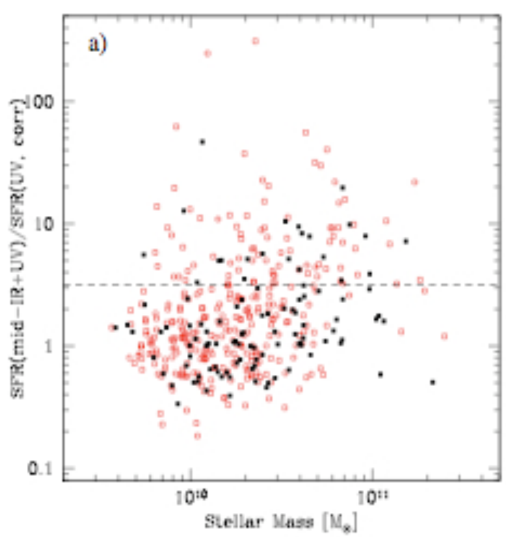
- F24um/FR>1000 R-K>4.5
- logF(1.5-4keV) stacked sources=-17 @z~2 $\log L_{obs}$(2-8keV) stacked sources ~41.8
- log<LIR>~44.8 ==> logL(2-8keV) unabs.~43
- Difference implies $\log N_H$~24

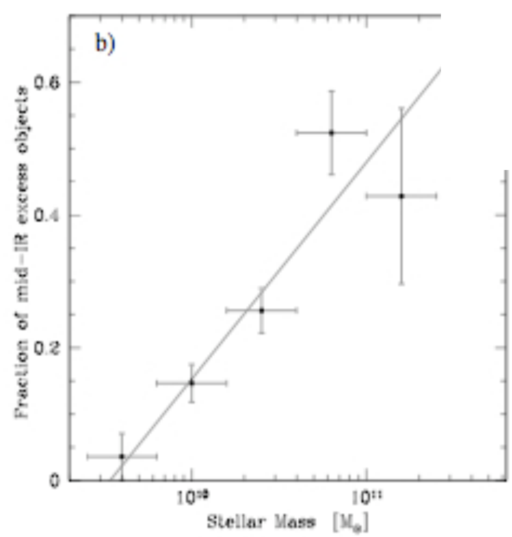
Fiore et. al. 2008a

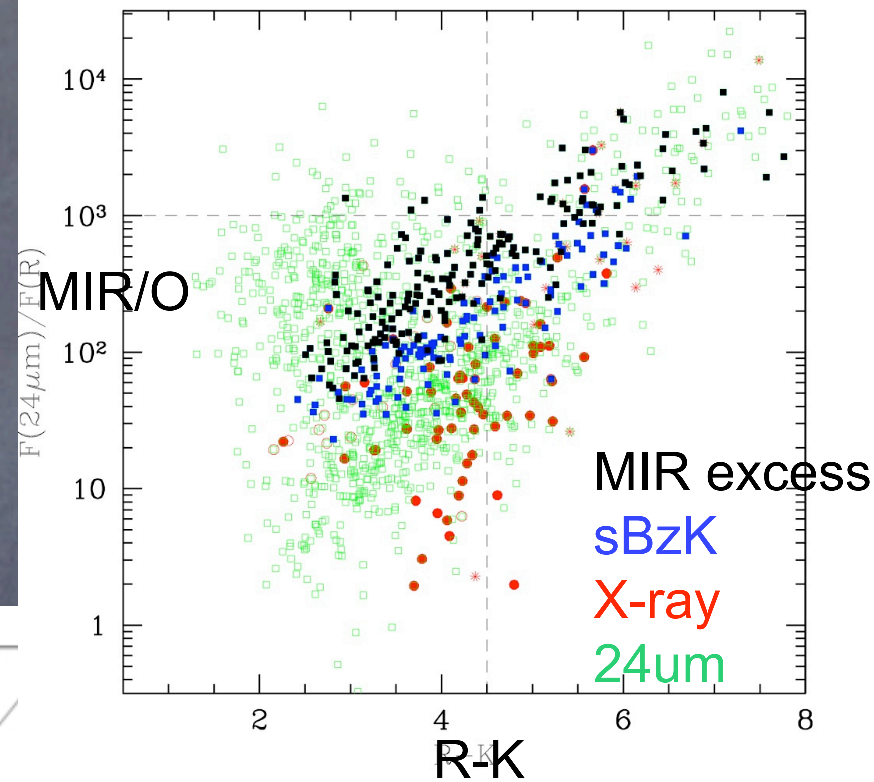
GOODS MIR AGN

Daddi et al 2007 selection of IR excesses from a sBzK sample

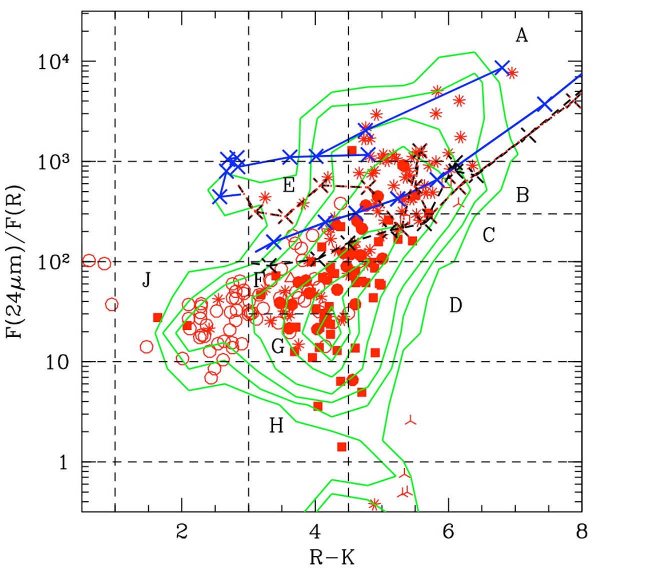


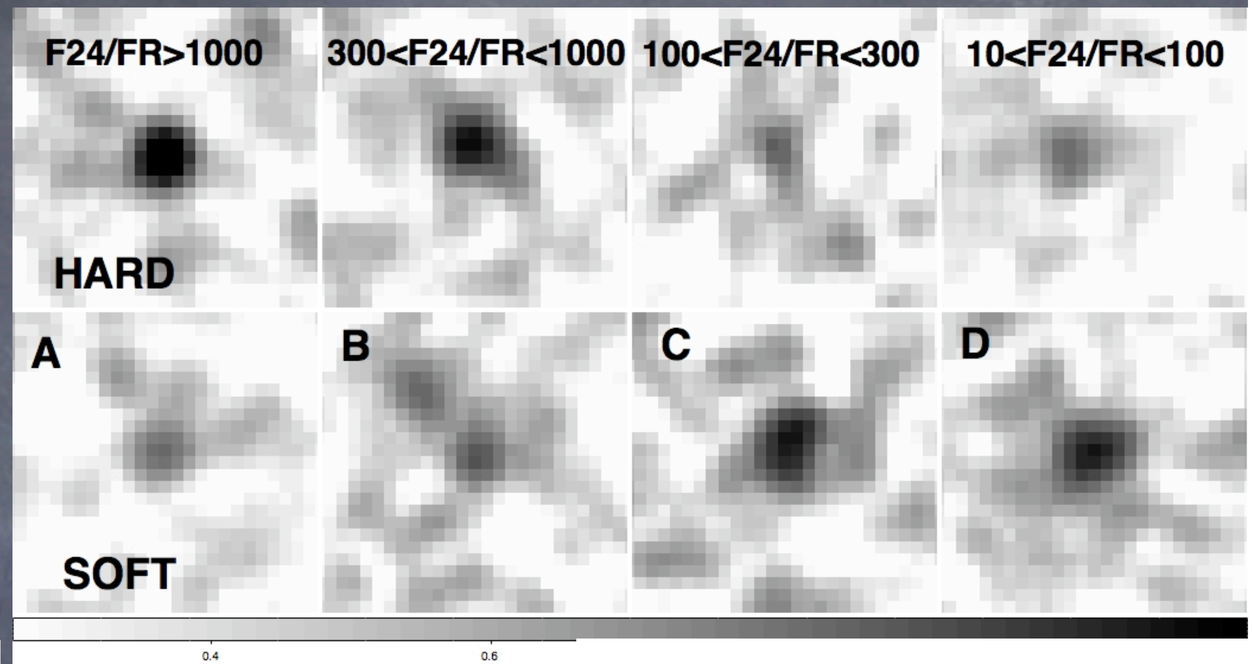


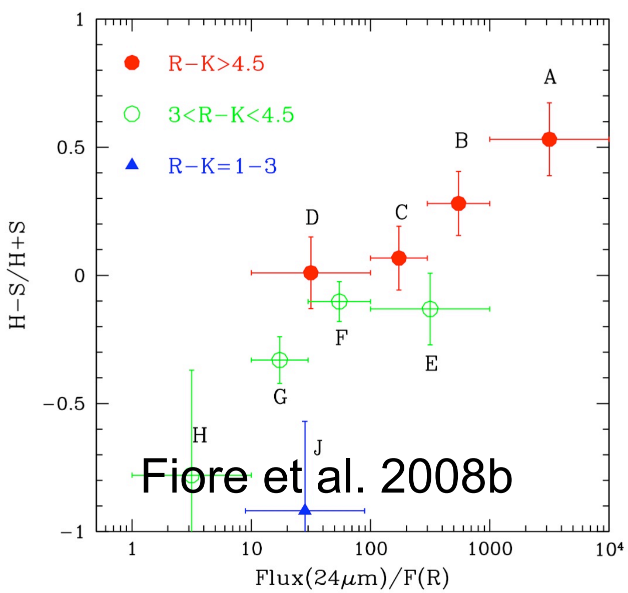


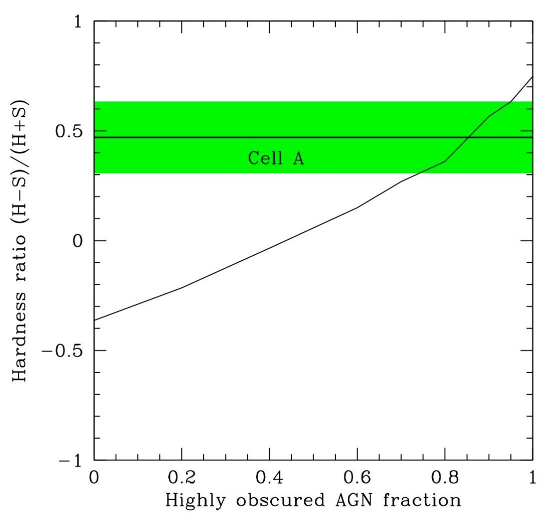


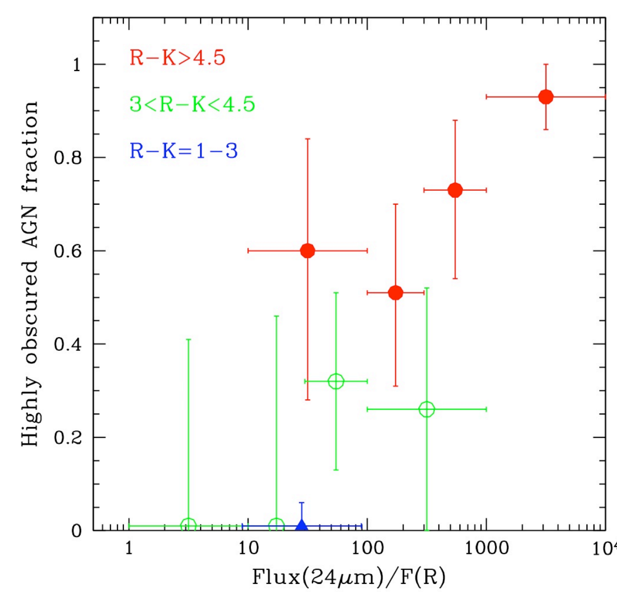
COSMOS MIR AGN



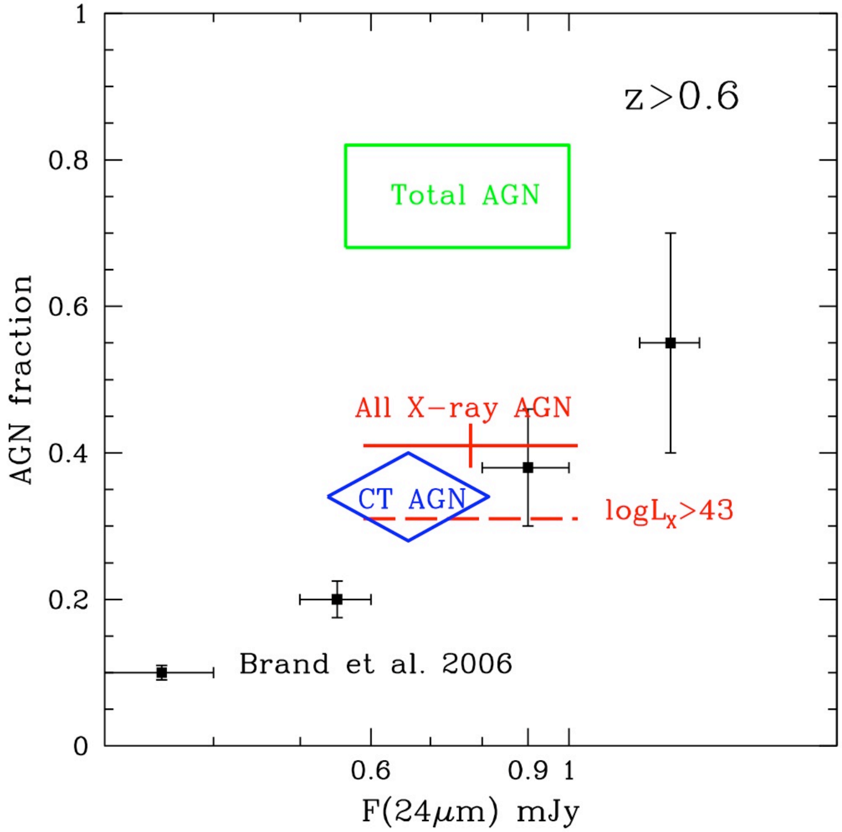


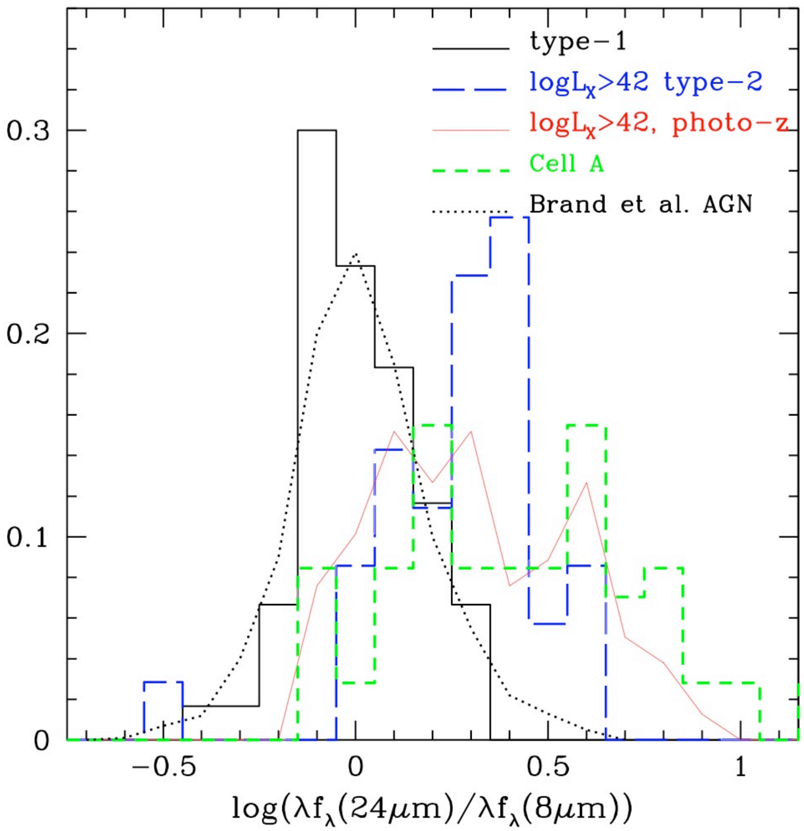




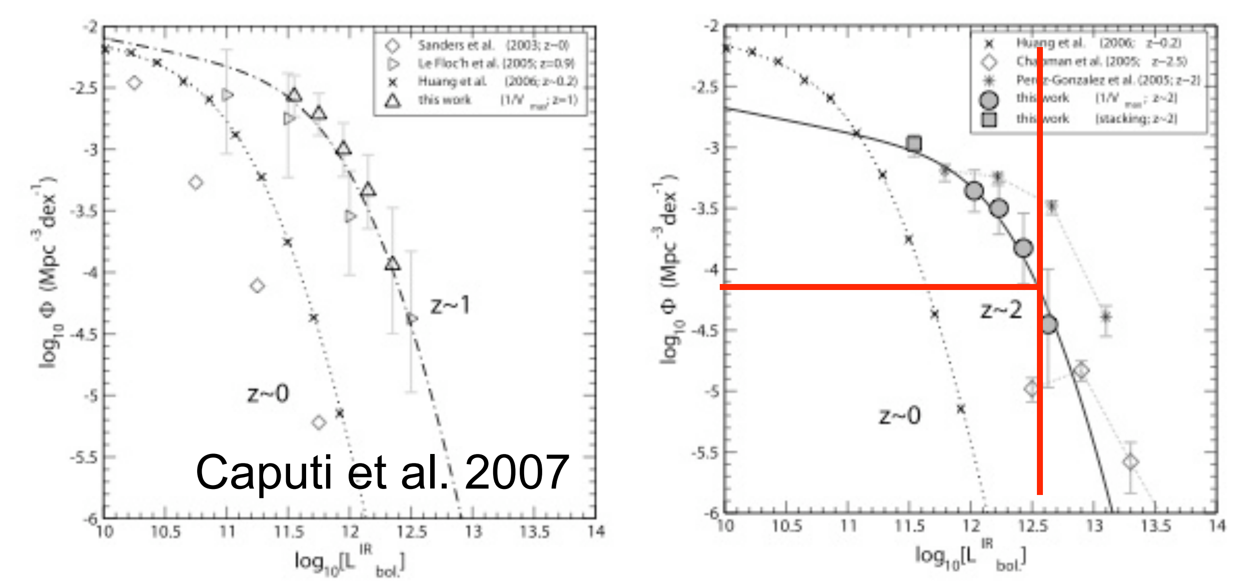


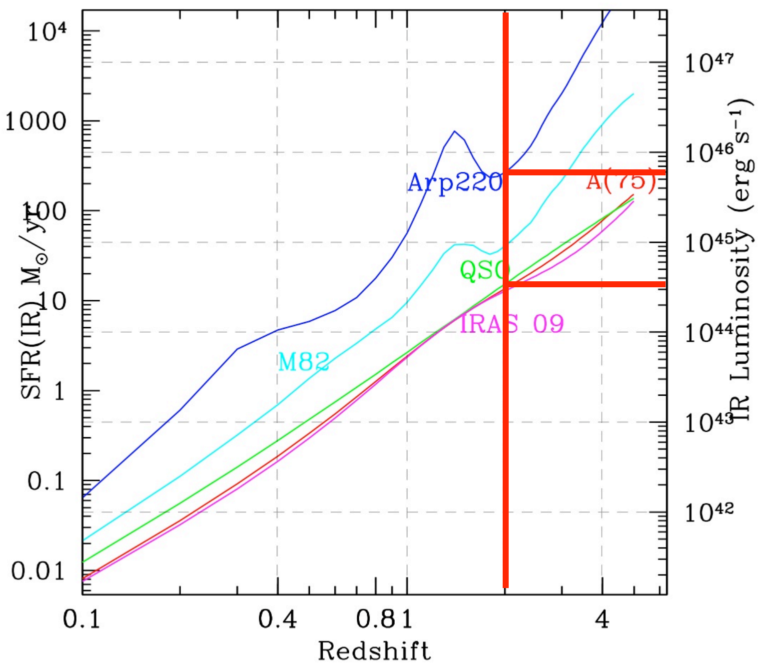
AGN fraction

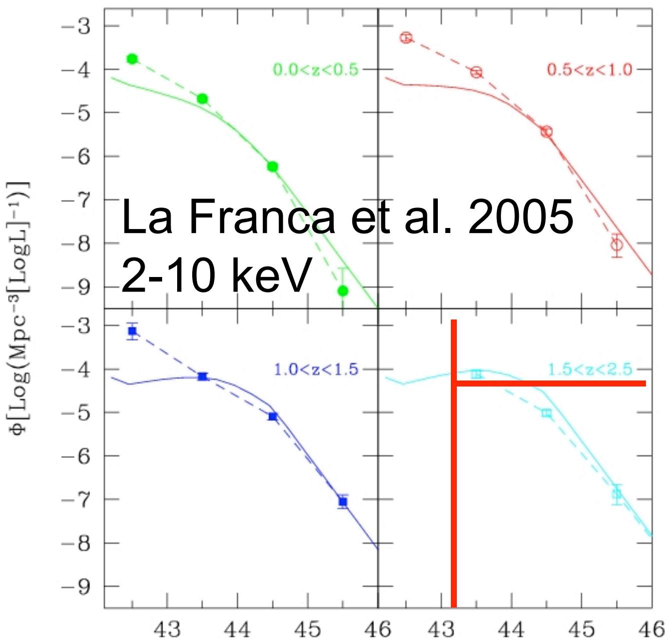




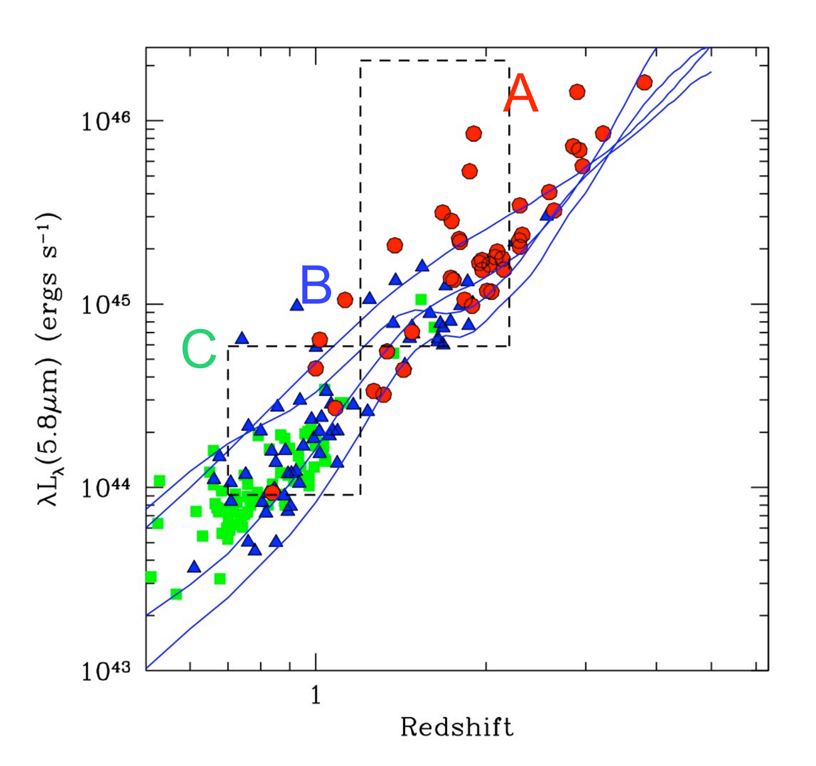
AGN fraction

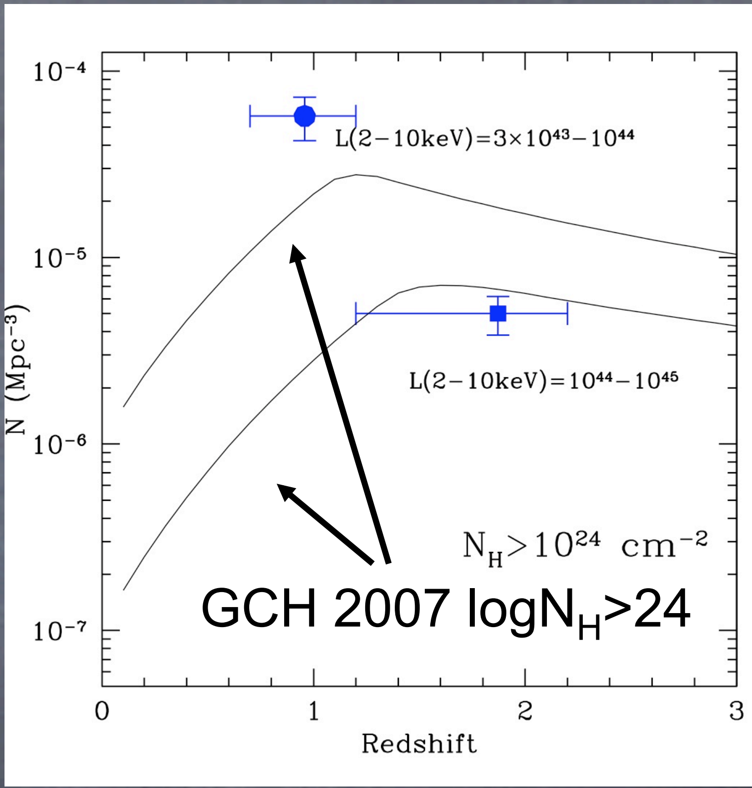






CT AGN volume density





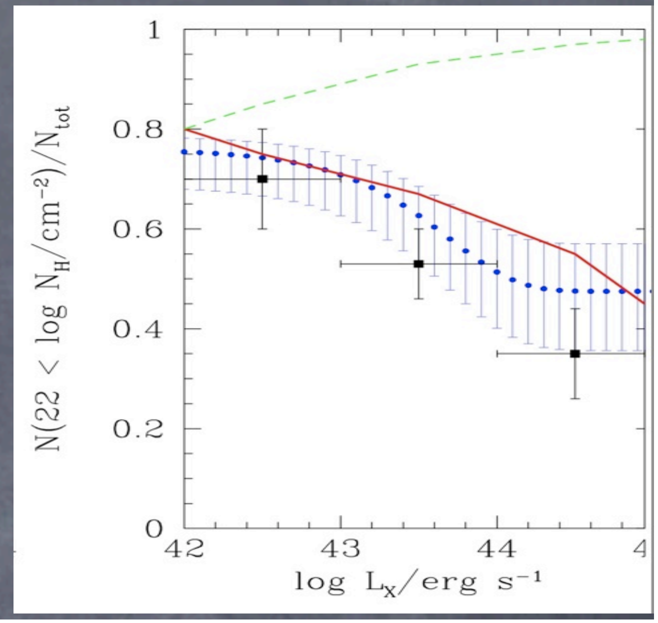
z=1.2-2.2: density IR-CT AGN ~ 45% density X-ray selected AGN, ~90% of unobscured or moderately obscured AGN

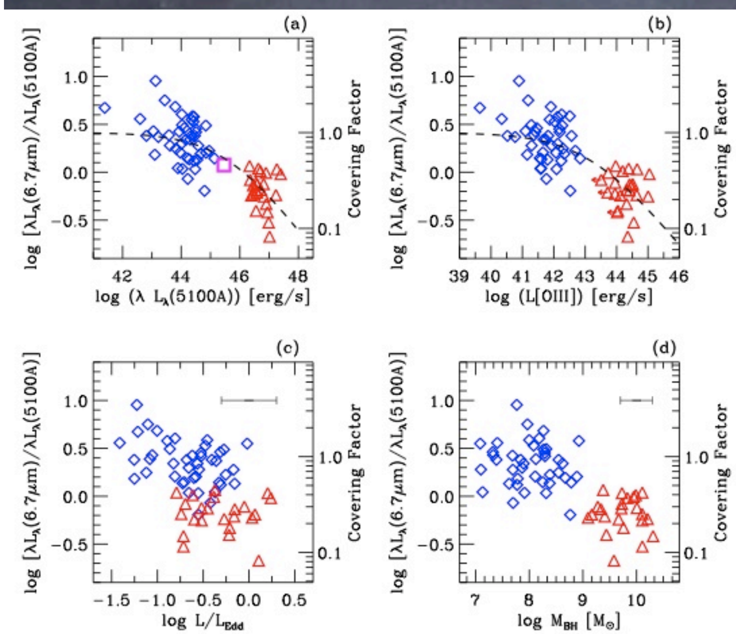
z=0.7-1.2: density IR-CT AGN ~ 100% density X-ray selected AGN, ~200% of unobscured or moderately obscured AGN

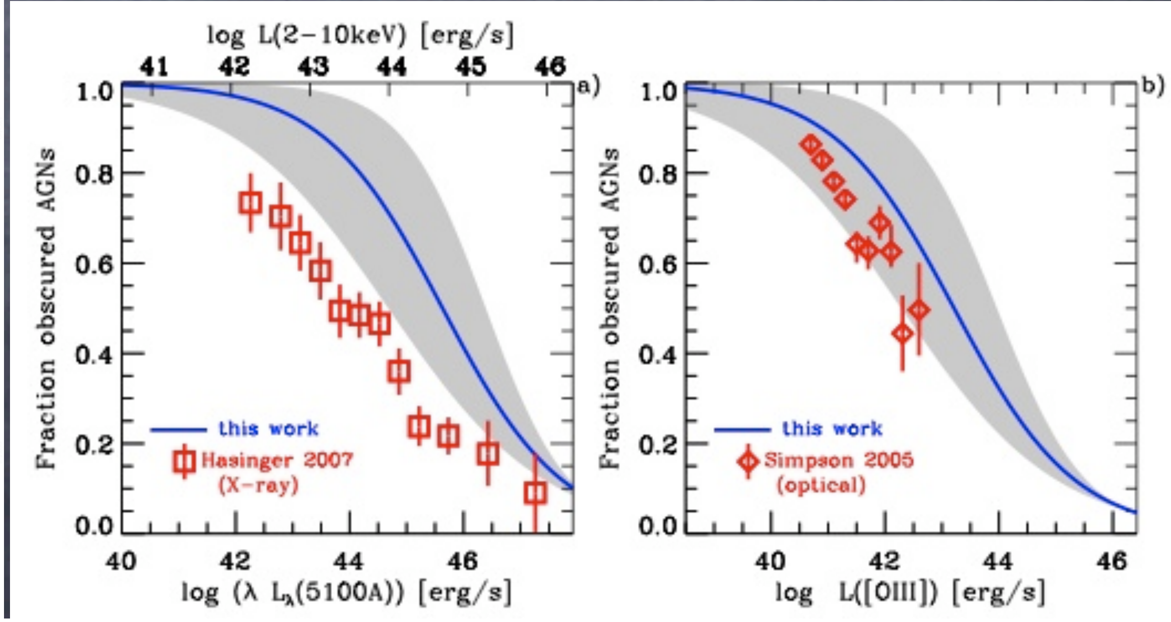
The correlation between the fraction of obscured AGN and their luminosity holds including CT AGN, and it is in place by z~2

Fraction of obscured AGN

- ***The correlation between the fraction of obscured AGN and their luminosity holds including CT AGN, and it is in place by z~2***
- **Consistent with:**
  - **La Franca et al. 2005 (X-ray selected AGN)**
  - **Maiolino et al. 2007 (luminosity dependent covering factor in unobscured AGN**







AGN obscuration, AGN feedback and star-formation

- CT absorbers can be naturally included in the Menci et al. feedback scenario as an extension toward smaller distances to the nucleus where gas density can be high.
- If this is the case and if the fundamental correlation between the fraction of obscured AGN and L is due to different timescales over which nuclear feedback is at work

$\downarrow$

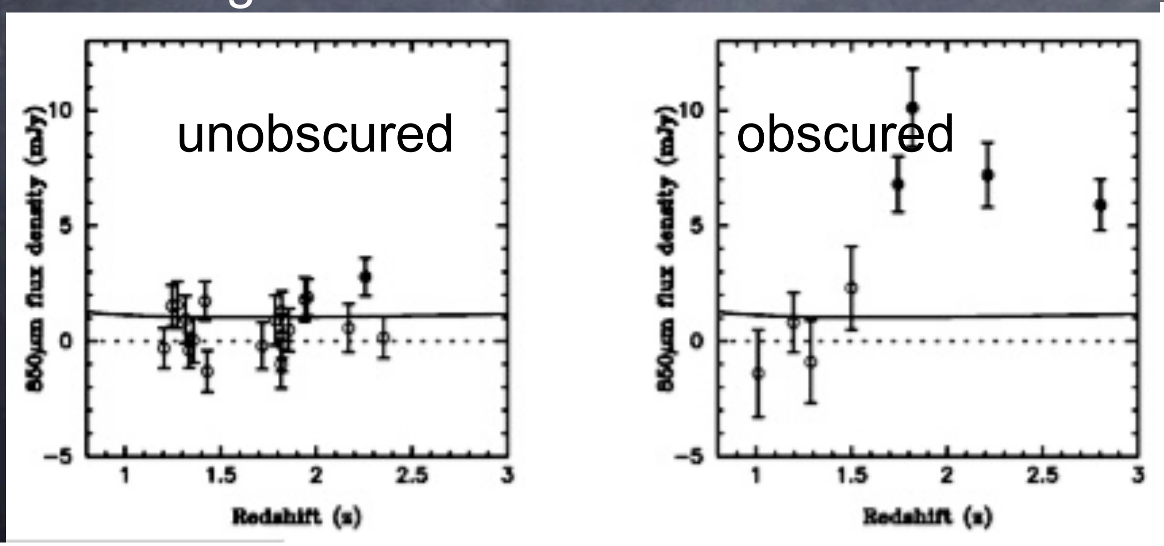
- Evolutionary star-formation sequence:
- CT $\longrightarrow$ moderately obscured $\longrightarrow$ unobscured
- Strong $\longrightarrow$ moderate $\longrightarrow$ small

AGN obscuration, AGN feedback and star-formation

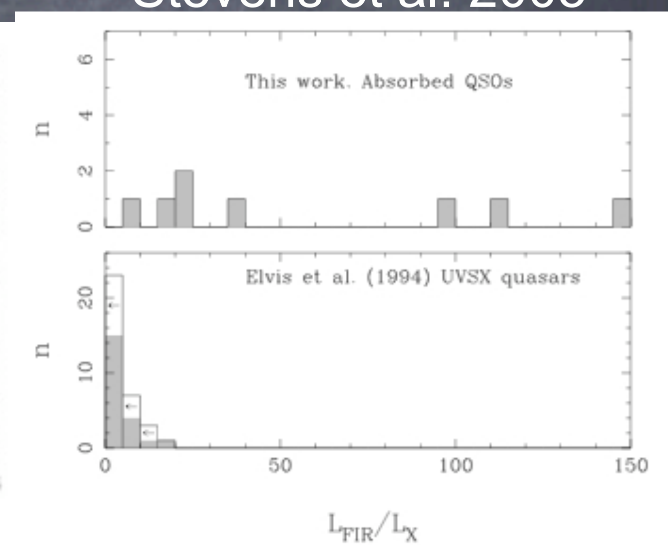
- COSMOS
  - Log(L5.8/L1.4GHz)=4.74 (0.12) 38 CT QSOs z=1.2-2.2

  - Log(L5.8/L1.4GHz)=5.07 (0.13) 25 QSOs z=1.2-2.2
- X-ray obscured QSOs have higher submm detection rate than unobscured QSO

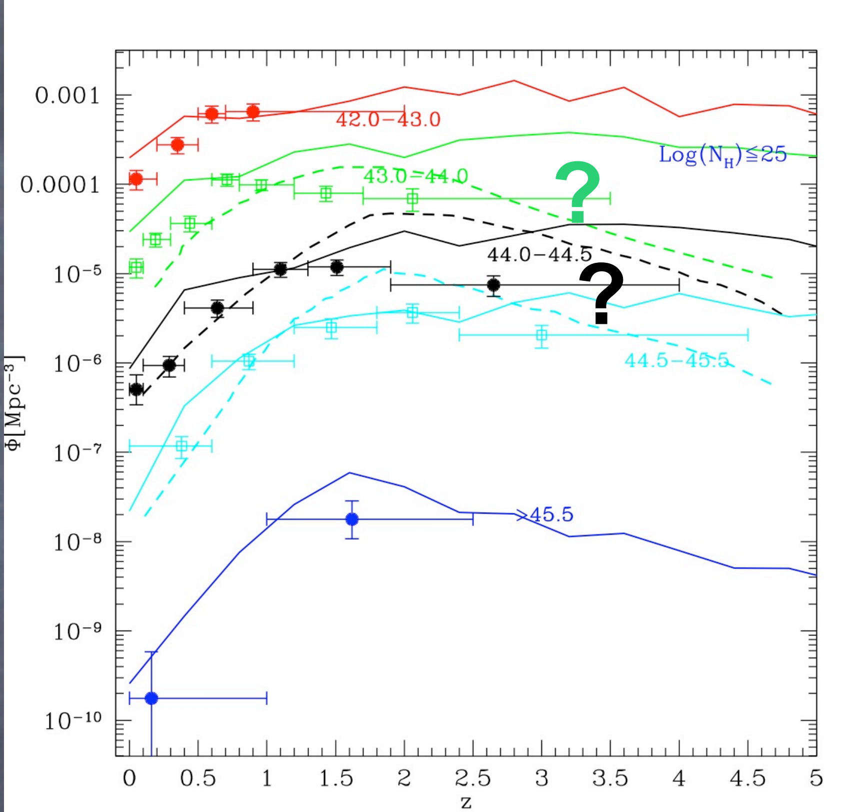
Page et al. 2004



Stevens et al. 2005



Density of Obscured AGNs



Dashed lines = Menci model, no AGN feeback
Solid lines = Menci model, AGN feedback 2-10 keV data = La Franca, FF et al. 2005
Spectroscopic confirmation:
very difficult for the CDFS-GOODS sources (R~27, F(24um)~100uJy
Possible for the COSMOS sources!! F24um~1mJy
==> Spitzer IRS AO5 program (Pri. C, Salvato et al.)

Summary

- XMM & Chandra surveys can probe unobscured and moderately obscured accretion up to z=2-4
- INTEGRAL/Swift find highly obscured AGN up to z~0.1
- Spitzer finds highly obscured AGN at z=1-2
- Obscured AGN fraction can be used to constrain AGN feedback models.

- Herschel will further increase the band, so helping in separating AGN from star-forming galaxies.
- During the next decade highly obscured AGN will be confirmed and studied in detail using hard X-ray focusing telescopes (Simbol-X, NuStar, NeXT).

- All this will allow a precise determination of the evolution of the accretion in the Universe, a precise census of accreting SMBH, and confirmation of AGN feedback models.